SEEDING RATES FOR MODERN GRAIN CORN HYBRIDS IN NEW YORK

A Thesis

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Master of Science

by

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ABSTRACT

Corn (*Zea mays* L.) seeding rates have increased in northern latitudes because new hybrids lodge less, have improved drought tolerance, and may respond more positively to higher rates in narrow rows. Farmer-researcher partnerships were formed to evaluate two recent hybrid releases at four seeding rates (61,750, 74,100, 86,450, and 98,800 kernels ha^{-1}) at a twin row site, a narrow row site (0.51 m rows), and two sites in 0.76 m rows in field-scale studies in 2011 and 2012 (warm and dry July conditions) in New York. Partial budget analyses were conducted to aid in future seeding rate decisions based on current market grain prices (\$265.76 Mg^{-1}), and seed (\$225 $80{,}000^{-1}$ kernels), drying (\$2.36 Mg^{-1} per 10 g kg^{-1} of moisture exceeding 150 g kg^{-1}) and hauling (\$7.87 Mg^{-1}) costs. Grain yield and relative profit responded inconsistently to seeding rates across locations, between hybrids, and between years at one location. Maximum relative profit exceeded the recommended seeding rate of 74,100 kernels ha^{-1} at the twin-row site (76,000 kernels ha^{-1}), at the narrow row site in 1 of 2 years (85,000-95,000 kernels ha^{-1}), but never at the 0.76 m row sites. The lack of a consistent response to seeding rates is probably related to dry July conditions, which contributed to decreases of 4 to 5 kernels $plant^{-1}$ as well as approximate 1 mg decreases with each 1000 kernel ha^{-1} increase in seeding rates at most sites. Based on the results of this study, recommended seeding rates in New York will not change.

BIOGRAPHICAL SKETCH

Geoffrey W. Reeves was born on 12 February, 1988 in Wichita, Kansas. He grew up in Burlington, Kansas and is the son of Glenn and Rebecca Reeves. He is a triplet, who has two-sisters, Erica and Alyssa. Geoff was recruited from high school to Cornell University to play varsity basketball whereupon his team was three-time Ivy League champions and advanced to the Sweet 16 round of the NCAA tournament his senior year, finishing with a school record 29 wins. He completed his undergraduate degree in agricultural sciences with concentrations in crop production and management as well as sustainable agriculture and was awarded a Bachelor of Science degree in May of 2010.

Geoff then worked for a year in the private agricultural industry as an independent consultant. He gained valuable experience in New York agriculture working with dairy, grain and vegetable farms across the state giving crop and pest management recommendations as well as creating nutrient management plans for livestock farms. During his employment he realized his desire to further his education and decided to return to Cornell to pursue a Master of Science degree in Agronomy.

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Thanks are extended to those who helped with data collection, including Phil Atkins and many other individuals.

A special thanks is extended to the farmers who collaborated in this research, taking the extra time necessary to manage these field-scale research plots. These collaborators include, in no specific order, Rodman Lott of Rodman Lott and Sons, Todd DuMond of DuMond Ag, LLC, Ron Gruschow of Sunny Knoll Farms and Todd Roberts of Roberts Farms. This work is done with the goal of benefitting farmers like these and could not have been executed without their investment.

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INTRODUCTION

Modern compared to older hybrids require greater plant densities to optimize yield (Tokatlidis and Koutroubas, 2004; Hammer et al., 2009). The introduction of Bt (*Bacillus thuringiensisI)* hybrid corn (*Zea mays* L.) to resist European Corn borer (ECB) [*ostrinia nubialis* (Hubner)] damage has reduced the risk of stalk lodging at these higher plant densities (Stranger and Lauer, 2006; Cox et al., 2009). Furthermore, modern hybrids have greater stress tolerance, which reduces the risk of barren plants at high plant densities (Lee and Tollenaar, 2007). Growers in northern states have increased their seeding rates, in part because of less risk of lodging and barren plants at high plant densities, as indicated by final corn densities in Iowa and Minnesota that averaged 75,500 plants ha^{-1} in 2011 (USDA-NASS, 2011) compared with 63,500 plants ha^{-1} in 1996 (USDA-NASS, 1996), the year that Bt corn was introduced. Another factor contributing to greater corn plant densities is the narrowing of row spacing in northern latitudes, which should allow corn to perform better at high plant densities (Butzen and Paszkiewicz, 2008). Seed prices, however, have increased significantly in the last 10 years (~$1.00 to ~$3.00/1000 kernels, Duffy, 2002, 2012), which is a deterrent to higher seeding rates. On the other hand, market prices for corn have increased dramatically in the last 5 years, which provides incentive for higher seeding rates if they result in higher yields. As new hybrids are released, row spacing narrows, seed costs increase, grain market prices vary, and uncertain weather conditions prevail, there is a need to regularly monitor the response of corn to seeding rates to determine economically optimum seeding rates and final plant densities across a range of locations and growing conditions (Cox, 1997; Widdicombe and Thelen, 2002; Stanger and Lauer, 2006).

Optimal plant density for corn can vary by location, primarily latitude, with greater plant densities in northern latitudes where heat and drought stress is less common (Widdicombe and Thelen, 2002). Optimum plant densities have been reported to exceed 80,000 plants ha^{-1} in the northern states of Wisconsin (83,300 plants ha^{-1}, Stranger and Lauer, 2006), Iowa (~90,000 plants ha^{-1}, Coulter et al., 2010) and Minnesota (82,000 to 84,500 plants ha^{-1}, Van Roekel and Coulter,2011, 2012). Recommended final plant densities in New York, however, remain at only 70,000 plants ha^{-1} when corn follows soybean {*Glycine max* (L.) Merr.} on silt loam soils, even under high-yielding conditions (Cox and Cherney, 2012). In more southern latitudes of the Corn Belt, optimum plant densities rarely exceed 69,000 plants ha^{-1} in Indiana (Robles et al., 2012) and have been reported at 61,800 plants ha^{-1} under rainfed conditions in Nebraska (Shapiro and Wortmann, 2006) probably because of more stressful growing conditions associated with heat and drought.

Stacked (two or more transgenic traits) corn hybrids with the Bt trait represented 67% of U.S. corn in 2012 (USDA-NASS, 2012). Stanger and Lauer (2006, 2007) reported that non-Bt corn had 22% more lodging than Bt corn but as plant density increased, the rate of increase for lodging increased for both Bt and non-Bt hybrids. Nevertheless, optimum plant densities for Bt corn (104,500 plants ha^{-1}) exceeded that of non-Bt corn (98,800 plants ha^{-1}, Stanger and Lauer, 2006). In studies where lodging was not significant, however, Singer et al. (2003) and Coulter et al. (2010) reported no differences in optimum plant densities between Bt and non-Bt hybrids. In field-scale studies (~5 ha) in New York, Cox et al. (2009) found that non-Bt hybrids exhibited 2.7-to-3.0-fold more stalk lodging below the ear compared with double and triple-stacked hybrids in continuous corn. Nevertheless, one site had 6-7% lodging in Bt hybrids, not associated with ECB damage, resulting in some harvest yield loss, which indicates that Bt corn reduces but does not eliminate the risk of lodging at high plant densities (Cox et al., 2009).

Narrow rows theoretically reduce intrarow competition among plants, which should allow corn in narrow rows vs. 0.76 m rows to yield greater at high plant densities (Butzen and Paszkiewicz, 2008). Grain yield increases with narrow rows are most common in the USA at latitudes north of 43^0 N (Lambert and Lowenberg-DeBoer, 2003; Lee, 2006; Butzen and Paszkiewicz, 2008). Consequently, row width averaged 0.51 m or less on about 5% of the corn hectares in Minnesota and Wisconsin in 2011, but only on 2.4% of the hectares in Iowa and Nebraska (USDA-NASS, 2011). Research studies from the late 1990s, however, reported no row spacing by plant density interaction in Minnesota (Porter et al., 1997), Iowa (Farnham, 2001), and Michigan (Widdicombe and Thelen, 2002). A more recent study by Van Roekel and Coulter (2012) in Minnesota also reported optimum corn plant densities of 84,000 plants ha^{-1} in 0.51 or 0.76 m rows, indicating that growers should not increase seeding rates if they adopt narrow row corn.

An alternative to planting in narrows rows is a twin-row configuration (Karlen and Camp, 1985). Robles et al. (2012), however, reported no row spacing by plant density interaction with optimum yields at a plant density of 69,000 plants ha^{-1} in 2 years and 81,000 plants ha^{-1} in another year in 0.76 m rows and twin rows in Indiana. Likewise, Novacek et al. (2012) reported no row spacing by plant density interaction under irrigated conditions in Nebraska with optimum plant densities for twin row and 0.76 m rows at seeding rates of 93,000 plants ha^{-1}. Both studies are consistent with earlier research from the Mid-Atlantic region (Kratochvil et al, 2005) where optimum plant densities were 63,000 plants ha^{-1} in both twin rows and 0.76 m rows. In the Southeast USA, however, a row spacing by plant density interaction was observed in Alabama where twin rows yielded best at about 81,000 plants ha^{-1} vs. about 62,000 plants ha^{-1} for 0.76 m rows (Balkcom et al., 2011). Likewise, under irrigated conditions in Mississippi, twin rows yielded 7% more than 0.76 m rows at plant densities of 75,000 and 85,000 plants ha^{-1} in one of two years (Bruns et al., 2012).

There is a limit to increasing plant density because interplant competition for light, water and nutrients can reduce yields (Duncan, 1984; Bullock et al., 1988). Corn typically exhibits a quadratic response to plant density, with a near-linear increase across a range of low densities, a gradual decreasing rate of yield increase relative to density increase, and finally a yield plateau at a certain plant density depending upon environmental conditions (Duncan, 1984). Environments with greater yield potential or a higher yield plateau require greater plant densities to optimize yield (Paszkiewicz and Butzen, 2007).The optimum plant density to attain the yield plateau is lower in environments limited by water (Shanahan et al., 2004) or in droughty years (Cox, 1996; Cox and Cherney, 2012). Nevertheless, modern hybrids tolerate droughty conditions much better than older hybrids because of the shortening of the anthesis-silking interval allowing for synchronous pollination (Edmeades et al., 2000), a decreased root angle resulting in deeper root penetration into the soil (Campos et al., 2006), improved kernel set at low plant growth rates at silking (Echarte and Tollenaar, 2006), and improved stay-green traits under drought stress during kernel fill (Lee and Tollenaar, 2007). Consequently, the yield advantage of modern compared with older hybrids is much greater at high compared with low plant densities (Hammer et al., 2009). Despite these improved traits, modern hybrids still respond differently to plant density because of differences in biomass plasticity and partitioning to the ear among hybrids (Sarlangue et al. 2007).

Most cited seeding rate studies have been conducted in small plot environments with research equipment that may be somewhat dated. Furthermore, many researchers overplant the experiment and thin to the desired final plant density. The first objective of this study was to validate recent small-plot research in New York (optimum seeding rates of 74,100 kernels ha^{-1}, Cox and Cherney, 2012) by evaluating two recent hybrid releases (2011) planted by growers under field-scale conditions with newly purchased corn planters, which presumably have superior metering and placement of seed compared to small plot research equipment. Growers purchased a narrow-row corn planter (0.51 m rows, in 2011), a twin-row planter (in 2011), and a planter with conventional row spacing (0.76 m rows, in 2011), respectively. The second objective of this study was to conduct partial budget analyses under grower conditions across predominant soil types in the major corn growing regions of New York to determine the optimum economic seeding rates and final plant densities for corn in the state.

MATERIALS AND METHODS

Farmer-researcher partnerships (Karlen et al., 1995) were formed to conduct field-scale studies in 2011 and 2012 on four farms in the major corn growing regions of Central and Western New York. Locations varied somewhat across years at each site to accommodate the request for soybean as the previous crop (Table 1). Predominant soil types on the four farms included Honeoye and Ontario silt loam (fine-loamy, mixed, superactive mesic Glossic Hapludalfs) at the Cayuga Co. site (42°52$^{/}$-42°59$^{/}$ N, 76°36$^{/}$-76°40$^{/}$ W) in 2011 and 2012, respectively, Honeoye silt loam (fine-loamy, mixed active mesic Glossic Hapludalfs) and Ovid silt loam (fine-loamy, mixed active mesic Aeric Ocrhaqualf) at the Livingston Co. site (42°53$^{/}$ -42°52$^{/}$ N, 77^{o}36$^{/}$ W) in 2011 and 2012, respectively, Appleton silt loam (fine-loamy, mixed active mesic Aeric Ocrhaqualf) and Hilton silt loam (fine-loamy, mixed active mesic Glossoboric Hapludalfs) at the Orleans Co.

site ($43^{o}14^{/}$ N, $78^{o}16^{/}$-$78^{o}17^{/}$ W) in 2011 and 2102, respectively, and Schoharie silt loam and Schoharie silty clay loam (fine-loamy, illitic, mesic Typic Hapludalfs) at the Seneca Co. site ($42^{o}51^{/}$-$42^{o}53^{/}$ N, $76^{o}49^{/}$-$76^{o}46^{/}$ W) in 2011 and 2012, respectively.

Farmers performed all field operations, including tillage practices (Table 1), planting, fertilizer applications, herbicide spraying, and harvesting. All sites except Cayuga County had consistent tillage practices across years (Table 1). Wet May conditions (Table 2) delayed planting until late May or early June at all sites except Seneca Co. in 2011 (Table 1). Growers at Livingston, Orleans, and Seneca Co. planted in mid-May in 2012, except for Cayuga Co. where the grower planted in mid-April.

The experimental design at each site was a randomized complete block in a split-plot arrangement, replicated three times, with two hybrids as main plots and four seeding rates as subplots. The growers planted 98-day (Minnesota Relative Maturity Rating) Bt Pioneer brand 'P9807' (Cry1F+Cry34/35Ab1 Bt events) and 99-day Bt DEKALB brand 'DKC49-94 GENSS' (Cry1Ab+Cry3Bb1 Bt events) hybrids with their respective planting equipment (9 or 12 m wide) at seeding rates of 61,750, 74,100, 86,450, and

Table 1. Plant and harvest date, row spacing, primary and secondary tillage practices, planter model and combine model at four New York locations in 2011 and 2012.

	Cayuga Co.		Livingston Co.		Orleans Co.		Seneca Co.	
Descriptor	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Plant date	28-May	18-Apr	1-Jun	16-May	6-Jun	15-May	11-May	19-May
Harvest date	20-Nov	17-Oct	14-Nov	12-Nov	7-Nov	11-Nov	15-Nov	19-Nov
Row Spacing (cm)	50.8		76.2		76.2 (twin-row)		76.2	
Primary tillage	strip-till	fall chisel	moldboard plow		disc	disc	no-till	no-till
Secondary tillage	--	spring disc	JD cultivator		--	--	--	--
Planter	John Deere 1790		John Deere 1770		Great Plains YP3025A-24TR		John Deere 1770NT	
Combine	John Deere 9770	John Deere S680	Case IH 6088		John Deere 9660 STS		John Deere 9770	

Table 2. Monthly and total accumulated growing degree days (GDD, 30°C/10°C system) and precipitation (Precip.) measured at the nearest weather station (within 15 km) for Cayuga, Livingston, Orleans and Seneca County sites during the 2011 and 2012 growing seasons.

	Cayuga Co.						Livingston Co.					
Month	**GDD (30/10)**			**Precip. (mm)**			**GDD (30/10)**			**Precip. (mm)**		
	2011	2012	30-yr-avg	2011	2012	30-yr-avg	2011	2012	30-yr-avg	2011	2012	30-yr-avg
May	201	245	176	129	41	79	191	247	174	114	62	71
June	282	283	286	75	62	96	309	294	281	83	85	83
July	402	388	358	24	66	90	401	399	350	19	89	86
August	333	348	338	166	76	80	331	348	326	118	57	87
September	244	229	227	146	85	103	253	230	219	64	96	85
Total	1462	1493	1384	541	331	447	1486	1518	1351	398	390	412

	Orleans Co.						Orleans Co.					
Month	**GDD (30/10)**			**Precip. (mm)**			**GDD (30/10)**			**Precip. (mm)**		
	2011	2012	30-yr-avg	2011	2012	30-yr-avg	2011	2012	30-yr-avg	2011	2012	30-yr-avg
May	191	244	187	155	39	77	191	242	164	101	45	77
June	298	316	300	62	76	76	296	283	276	52	60	93
July	429	412	376	36	38	78	406	402	353	23	88	87
August	360	361	353	113	32	78	338	353	328	127	50	78
September	258	250	242	48	102	90	238	227	212	100	68	88
Total	1536	1582	1458	414	288	399	1470	1507	1333	403	310	425

98,800 kernels ha^{-1}. Main plots measured about 500 m in length at Cayuga and Seneca Co., 400 m at Livingston Co., and 150 m at Orleans Co. Growers at Livingston, Orleans, and Seneca Co. applied some N at planting and side-dressed the remaining N in late spring. The grower at Cayuga Co, who planted in 0.51 m rows, applied the entire amount of N at planting. Growers at all sites used their typical preemergence herbicides and also applied Glyphosate [*N*-(phosphonomethyl)glycine] at the 3rd to 5th leaf (V3-5, Ritchie et al., 1993) stage.

Final plant densities of each subplot (hybrid by seeding rate) were estimated by three individuals at the V4 stage by counting all the plants along the 150 to 500 m length, depending upon the site, in the middle two rows while walking up and down the entire length of each subplot. Each individual counted one replication and then measured plot length of each subplot with a bicycle wheel to eliminate any inconsistencies in counting or measuring plot length among individuals. Growers at all sites harvested the entire length and partial width of each subplot in mid-November (Table 1), except for mid-October at Cayuga Co. in 2012, with their respective combines (Table 1). Combine width ranged from 4.5 to 7.5 m at each site except at Cayuga Co. where the width was 9 m in 2012. A researcher rode in the combine with the farmer and counted all the plants that were visibly lodged below the ear in the same rows that final plant densities were determined at the V4 stage, which allowed for an accurate estimate of percent lodged plants. Although the combines were equipped with yield monitors, each subplot was weighed with calibrated Weigh Wagons or grain carts to minimize any calibration errors with the yield monitors.

Two grain samples were taken from each subplot and moistures and kernel density were determined the following day in the lab with a grain moisture meter and kernel density cup. Grain yields were then adjusted to 155 g kg $^{-1}$ moisture, as was kernel density using the equation {Adjusted kernel density = [(100 - 15.5) /(100 - Actual Moisture Content)], Hellevang, 1995}. In addition, a seed counter (Old Mill Co., Savage, MD) was used to count 1000 kernels from each sample, which were then weighed to determine individual kernel weight. Kernels plant^{-1} was then determined by dividing the grain yield by the weight of the individual kernel and the estimated final plant densities.

A partial budget approach was used to estimate the expected change in annual profit in an average future year for seeding rates at each site. Only variable costs were analyzed, which included seed costs for the 2011-2012 growing seasons (average of \$225/80,000 kernels paid by the participating farmers for seed in 2011 and 2012), hauling costs to the farm (\$7.87 Mg^{-1}, USDA-NASS, 2011, 2012), and drying costs, (\$2.36 Mg^{-1} to remove 10 g kg^{-1} of moisture in excess of 150 g kg^{-1}, USDA-NASS, 2011, 2012). The corn grain price averaged \$265.76 Mg^{-1} for the 2011-2012 marketing years in NY (New York Agricultural Statistics Service, 2012). We did not include storage, and hauling to market as variable costs in this economic analysis because of different selling procedures on each farm (i.e. one farmer sold the crop to an ethanol plant contiguous with his farm, one sold the crop to a neighboring dairy farm, and two farmers stored and marketed the crop over the year to different buyers). All dollar values for income and cost items are expressed in real terms as 2012 dollars. The expected changes in profit reflected differences in total net income (increases or decreases) and differences in selected variable costs (increases and decreases) for the four farms in this study for a future average year.

Statistical analyses were performed using the JMP 10.0 Pro statistical package (SAS Institute, 2010). Hybrids and seeding rates were considered fixed and years and reps random in the ANOVA model. The Restricted Maximum Likelihood (REML) model platform was used in JMP to fit the mixed regression models. Because of differences in row widths, planting dates, soil types as well as non-homogenous variances across sites for yield and profit, each site was analyzed separately. Variances were homogeneous across years for most measured variables at each site except for non-homogeneous variances across years (Bartlett test, <0.01) at the Cayuga Co. site for yield, kernels plant^{-1}, and relative profit. When variances were non-homogenous, separate analyses were performed on the data for each year. Also, the Shapiro–Wilk statistic indicated normalcy for all data except % lodging. Log transformation of the lodging data was performed on this one data set for statistical analysis and regression equations will be presented as so in the table.

Linear or quadratic regression equations were developed on all measured variables with seeding rates or final plant densities as the independent variable across years when variances were normal (n=48). If variances were not normal, linear or quadratic regression equations were developed on those variables within years (n=24). Hybrid differences were considered significant if P-values were <0.1 in the ANOVA test. If hybrid by seeding rate interactions did not exist in the ANOVA, single regression equations were used. If hybrid by seeding rate interactions were significant in the ANOVA (α=0.1), separate linear and quadratic equations were developed for each hybrid (n=24 or n=12 depending on weather combined or not combined across years). Linear and quadratic coefficients were considered significant at P-values <0.1.

RESULTS AND DISCUSSION

Growing Conditions

Growing degree days (GDD) and total precipitation from May through September varied more among sites than between years (Table 2). Both years had below-average precipitation, especially in June and July of 2011 and July and August of 2012. Also, both years had above-average GDD, especially in July of both years when most sites exceeded 400 GDD, 30-75 GDD above-normal. Despite much above-average GDD from May through July of 2011, the delay in planting date due to wet May conditions also delayed the silking (R1) stage of both hybrids until early August at all sites (except Seneca Co. site). Timely precipitation relieved dry conditions in early August during the R1 stage and subsequent precipitation (more than 100 mm at all sites in August, most sites in September) allowed stress-free conditions from the R1 through physiological maturity (R6). Consequently, despite the delay in planting date and dry and warm conditions in July, yields in 2011 averaged 11.8 Mg ha^{-1} across sites. The Seneca Co. site, however, which was planted in mid-May and at the R1 stage in mid-July, had an average yield of 10.4 Mg ha^{-1} in 2011.

In 2012, both hybrids attained the R1 stage around 20 July at all sites (except 12-13 July at the April-planted Cayuga Co. site). Most of the July precipitation in 2012 occurred during the last 10 days of the month and most of the August precipitation occurred during the first half of the month. Consequently, both hybrids at all sites, except Cayuga Co., were drought-free during the critical R1 through early kernel fill (R4 stage) in 2012, resulting in average yields of 10.5 Mg ha^{-1}. The April-planted Cayuga Co. site, however, had average yields of only 8.9 Mg ha^{-1} in 2012, 25% less than in 2011.

Livingston Co.-0.76 m Rows

When averaged across years, hybrid and seeding rate did not affect yield and there was no hybrid x seeding rate interaction (Fig. 1). Likewise, final plant densities, which averaged about 96% of seeding rates at this site, also did not affect yield and there was no hybrid x plant density interaction (Table 3). The Livingston Co. site had the highest average yield (12.5 Mg ha^{-1}) in this study so it was expected to have optimum plant densities of about 92,000 plants ha^{-1} based on the plant density-yield data model of Butzen and Paszkiewicz (2008). Perhaps the dry July conditions of 2011 and somewhat dry August conditions of 2012 muted the yield response to seeding rates at this site.

Kernels $plant^{-1}$ showed negative quadratic responses to seeding rates (Fig. 2) and final plant densities (Table 3), with no hybrid interactions. Kernels $plant^{-1}$ typically shows a negative linear response to final plant densities (Cox, 1996; Borrás et al., 2007; Echarte et al., 2008; Boosma et al., 2009; Ciampitti and Vyn, 2011; Cox and Cherney, 2012) so the significance of the quadratic term, although slight, was unexpected. When averaged across hybrids, kernels $plant^{-1}$ decreased from 610 kernels $plant^{-1}$ at the lowest seeding rate to 417 kernels $plant^{-1}$ at the highest seeding rate, a 32% decrease. Interestingly, a recent study in New York in the dry 2011 growing season with two different hybrids also showed a 32.5% decrease in kernels $plant^{-1}$ at similar seeding rates (Cox and Cherney, 2012).

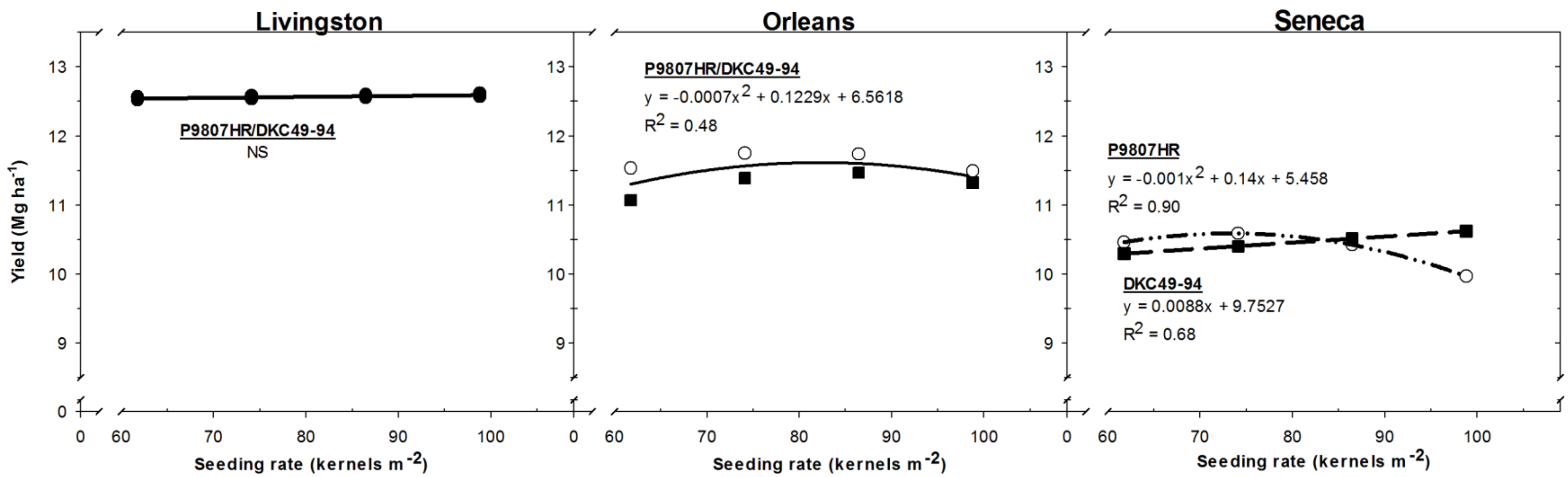

Figure 1. Relationship between grain yield and seeding rate within sites for two corn hybrids (——, combined across hybrids; ○, —··—··—, 'P9807HR'; ■, — — —,'DKC49-94').

Table 3. Parameter estimates, R^2 values, and model significance values for regression models relating plant density to yield, relative profit, kernels per plant and kernel weight for sites, years and hybrids.

Dependent variable				Parameter estimate				
Site	Year	Hybrid	Model†	$\widehat{\beta_0}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$	R^2	Model Significance‡
Yield (Mg ha^{-1})								
Cayuga	2011	P9807	L	11.1	0.0189	--	0.57	*
		DKC49-94	Q	1.5	0.2482	-0.0014	0.76	**
	2012		NS					
Livingston	2011-2012		NS					
Orleans			NS					
Seneca		P9807	Q	12.1	-0.0382	-0.0002	0.87	**
		DKC49-94	L	9.6	0.0114	--	0.7	**
Relative profit ($ ha^{-1})								
Cayuga	2011	P9807	NS					
		DKC49-94	Q	5498.8	-89.624	0.6669	0.7	**
	2012		NS					
Livingston	2011-2012		NS					
Orleans			NS					
Seneca		P9807	Q	1343.5	33.142	-0.24449	0.87	***
		DKC49-94	NS					
Kernels per plant								
Cayuga	2011		L	958.0	-6.1695	--	0.82	***
	2012		Q	694.5	-5.0398	0.1276	0.95	***
Livingston	2011-2012		Q	912.2	-5.3396	0.0356	0.97	**
Orleans	2011-2012		Q	955.7	-5.9138	0.0634	0.94	**
Seneca	2011-2012	P9807	L	830.0	-5.2608	--	0.99	***
		DKC49-94	L	762.5	-4.1767	--	0.95	***
Kernel Weight (mg)								
Cayuga	2011-2012		L	378.8	-0.463	--	0.65	**
Livingston		P9807	L	410.3	-1.0487	--	0.90	***
		DKC49-94	Q	381.0	-0.6474	0.0097	0.98	**
Orleans			Q	362.1	-0.8146	0.0274	0.89	**
Seneca			L	397.2	-0.9762	--	0.81	***

† L, linear regression model; Q, quadratic regression model; NS, non-significant response to plant density

‡ Model significance indicated by * at α=0.10, ** at α=0.05, and * at α=0.01**

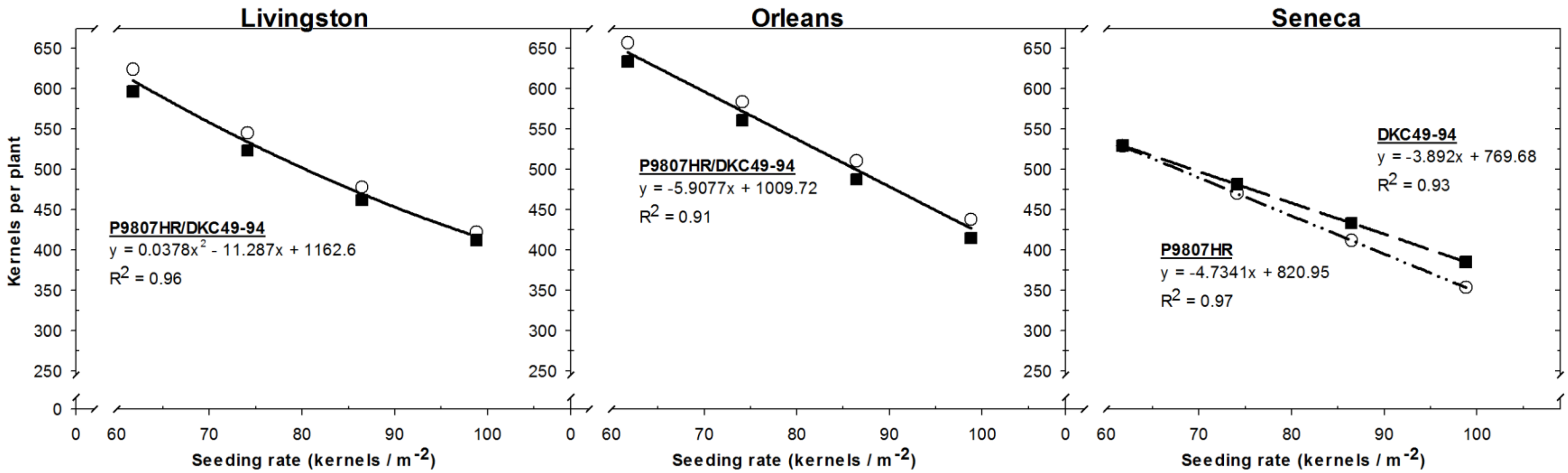

Figure 2. Relationship between kernels per plant and seeding rate within sites for two corn hybrids (——, combined across hybrids; ○ , —··—··, 'P9807HR'; ■ , — — — —,'DKC49-94').

When averaged across years and seeding rates, the Pioneer hybrid had more kernels plant^{-1} (517) compared with the DEKALB hybrid (498). When averaged across years, kernel weight had hybrid x seeding rate (Fig. 3) and hybrid x plant density interactions (Table 3). Kernel weight had negative quadratic responses to seeding rates (greater quadratic term for the Pioneer hybrid) with minimum kernel weights occurring at the highest seeding rates (>98,800 kernels ha^{-1}) for both hybrids, which is consistent with previous studies (Cox, 1996; Boomsma et al., 2009; Borrás and Gambin, 2010; Ciamapitti and Vy, 2011, Van Roekel and Coulter, 2011). Kernel weight of the Pioneer hybrid had a negative linear response, whereas kernel weight of the DEKALB hybrid had a negative quadratic response to final plant densities. The DEKALB hybrid, which had less kernels plant^{-1} than the

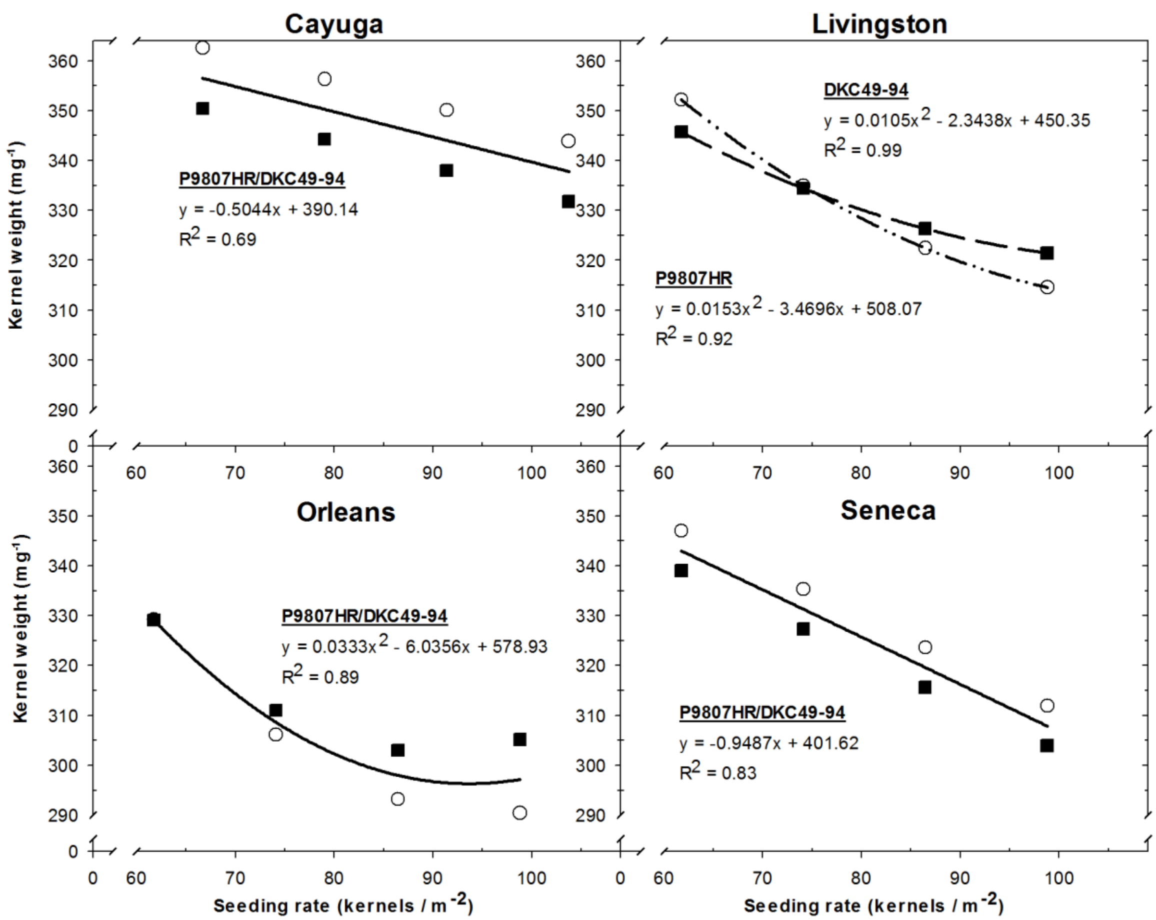

Figure 3. Relationship between kernel weight and seeding rate within sites for two corn hybrids (——, combined across hybrids; ○, —··—··, 'P9807HR'; ■, — — —,'DKC49-94').

Pioneer hybrid, could have showed a negative quadratic instead of the typical negative linear response to plant density because its lower kernel number may have allowed for less competition for assimilates and not as great a reduction in kernel weight at the high seeding rates in both dry growing seasons. Regardless, the 32% decrease in kernels plant^{-1} and 9% decrease in kernel weight from the lowest to highest seeding rate offset the increase in number of plants ha^{-1}, resulting in no yield response by either hybrid to seeding rates or plant densities at this site.

Grain moisture did not respond to seeding rates in 2011 but there were hybrid x seeding rate (Table 4) and hybrid x plant density interactions (Table 5) in 2012. Differences among seeding rates and plant densities for the responsive DEKALB hybrid in 2012, however, were not of sufficient magnitude (<5 g kg^{-1}) to be of practical significance. Also, kernel density had hybrid x seeding rate interactions with generally negative linear responses (Tables 4 and 5). Nevertheless, kernel density values exceeded the docking threshold (695 kg m^{-3}) by grain mills for all seeding rates so the negative linear response was of no practical significance. Likewise, % lodging had linear responses to seeding rates (Table 4) but maximum values were only 2.6% at the highest seeding rate, which probably did not affect grain yield. The Pioneer hybrid did have greater lodging (2.0%) compared with the DEKALB hybrid (0.9%) and greater grain moisture in 2011 (215 g kg^{-1}) compared with the DEKALB hybrid (211 g kg^{-1}). Partial budget analyses indicate that relative profit did not respond to seeding rate and plant densities and there were no hybrid x seeding rate or plant density interactions (Fig. 4 and Table 3). Van Roekel and Coulter (2011) reported maximum net returns at plant densities of 80,000-85,000 plants ha^{-1} at comparable seed costs and corn prices as used in a planting date by plant density study in Minnesota. In a recent row spacing by plant density study, however, Van Roekel and Coulter (2012) reported no differences in net returns to plant densities ranging from 38,400 to 107,900 plants ha^{-1} unless seed costs were high ($350/80,000 kernels) and grain prices were low ($120 Mg^{-1}) or seed costs were low ($150/80,000 kernels) and grain prices were high ($280 Mg^{-1}). The grower at this site typically plants all his hybrids at 88,920 kernels ha^{-1}, and would not have lost profit at this seeding rate, despite the lack of response, because relative profit was the same across all seeding rates.

Table 4. Parameter estimates, R^2 values, and model significance values for regression models relating seeding rate to percent lodging, grain moisture and kernel density for sites, years and hybrids.

Dependent variable				Parameter estimate				
Site	Year	Hybrid	Model†	$\widehat{\beta_0}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$	R^2	Model Significance‡
Percent lodging (log-scale)								
Cayuga	2011-2012		L	-1.5	0.0116	--	0.56	*
Livingston			L	-1.9	0.0212	--	0.77	**
Orleans			L	-3.7	0.0369	--	0.63	**
Seneca			L	-4.3	0.0299	--	0.67	***
Grain moisture (g kg^{-1})								
Cayuga	2011	P9807	NS					
		DKC49-94	L	210.9	-0.2146	--	0.68	***
	2012		NS					
Livingston	2011		NS					
	2012	P9807	NS					
		DKC49-94	L	203.9	-0.2281	--	0.78	***
Orleans	2011		L	274.8	-0.2901	--	0.56	*
	2012		NS			--		
Seneca	2011		NS			--		
	2012	P9807	Q	222.8	-0.9791	0.0057	0.88	*
		DKC49-94	L	197.1	-0.2686	--	0.84	**
Kernel density (kg m^{-3})								
Cayuga	2011-2012		NS					
Livingston		P9807	L	1182.7	-4.2355	--	0.68	**
		DKC49-94	L	735.8	-0.2802	--	0.71	**
Orleans			L	747.8	-0.4181	--	0.33	**
Seneca		P9807	NS					
		DKC49-94	L	775.5	-0.5938	--	0.67	***

† L, linear regression model; Q, quadratic regression model; NS, non-significant response to seeding rate
‡ Model significance indicated by * at α=0.10, ** at α=0.05, and * at α=0.01**

Table 5. Parameter estimates, R^2 values, and model significance values for regression models relating plant density to percent lodging, grain moisture and kernel density for sites, years and hybrids.

Dependent variable				Parameter estimate				
Site	Year	Hybrid	Model†	$\widehat{\beta_0}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$	R^2	Model Significance‡
Percent lodging (log-scale)								
Cayuga			NS					
Livingston	2011-2012		L	-1.8	0.0207	--	0.76	**
Orleans			L	-3.3	0.0349	--	0.65	**
Seneca			L	-3.9	0.0281	--	0.64	***
Grain moisture (g kg-1)								
Cayuga	2011	P9807	NS					
		DKC49-94	L	213.1	-0.3242	--	0.34	**
	2012		NS					
Livingston	2011		NS					
	2012	P9807	NS					
		DKC49-94	L	202.9	-0.2201	--	0.70	**
Orleans	2011		L	274.3	-0.3225	--	0.59	**
	2012		NS					
Seneca	2011		NS					
	2012	P9807	Q	213.7	-0.8565	0.0056	0.9	**
		DKC49-94	L	198.3	-0.3257	--	0.82	**
Kernel density (kg m^{-3})								
Cayuga			NS					
Livingston		P9807	NS					
		DKC49-94	L	736.7	-0.297	--	0.73	**
Orleans	2011-2012	P9807	NS					
		DKC49-94	L	768.3	-0.7014	--	0.46	**
Seneca		P9807	NS					
		DKC49-94	L	766.1	-0.5234	--	0.60	***

† L, linear regression model; Q, quadratic regression model; NS, non-significant response to plant density
‡ Model significance indicated by * at α=0.10, ** at α=0.05, and * at α=0.01**

Orleans Co.-Twin Rows

When averaged across years, hybrid and seeding rate affected yield and there was no hybrid x seeding rate interaction (Fig. 1). Surprisingly, final plant densities, which averaged about 92% of seeding rates at this site, had no hybrid, plant density, or hybrid x plant density interaction for yield (Table 3). In this twin-row study, maximum yield as predicted by the quadratic equation was observed at a seeding rate of 87,785 kernels ha^{-1}. The Orleans Co. site had an average yield of 11.5 Mg ha^{-1} in this study so it was expected to have optimum plant densities of about 88,700 plants ha^{-1}, based on the plant density-yield data model of Butzen and Paszkiewicz, (2008). The results at this twin row site agree with the findings of Balkcom et al., (2011) and Bruns et al. (2012) in the Southeast USA where twin row corn had maximum yield at seeding rates above 80,000 kernels ha^{-1}. Interestingly, the yield difference was only 1.7% for 74,100 kernels ha^{-1} (11.5 Mg ha^{-1}), the recommended seeding rate in New York, vs. 86,450 kernels ha^{-1} (11.7 Mg ha^{-1}). This is very similar to the 1.5 to 2.0% yield difference for 74,100 vs. the 86,450 kernels ha^{-1} for maximum yield in small-plot research in New York in 2010 and 2011 (Cox and Cherney, 2012). The Pioneer hybrid (11.6 Mg ha^{-1}) yielded 2.7% greater than the DEKALB hybrid (11.3 Mg ha^{-1}) at this site.

Kernels plant^{-1} showed a negative linear response to seeding rates (Fig. 2) and a negative quadratic response to final plant densities with no hybrid interactions (Table 3). When averaged across hybrids, kernels plant^{-1} decreased from 645 kernels plant^{-1} at the lowest seeding rate to 432 kernels plant^{-1} at the highest seeding rate, a 33% decrease, very similar to the decrease at Livingston Co. When averaged across years and seeding rates, the Pioneer hybrid had more kernels plant^{-1} (547) compared with the DEKALB hybrid (532), similar to the results at Livingston Co.

When averaged across years, kernel weight had quadratic responses to seeding rates (Fig. 3) and plant densities (Table 3) with no hybrid x seeding rate or plant density interactions. At this site, the 22% decrease in kernels plant^{-1} and 8.5% decrease in kernel weight from the lowest seeding rate to the 86,450 kernels ha^{-1} seeding rate did not offset the 29% increase in number of plants ha^{-1}, resulting in the quadratic response with maximum predicted yields at 87,785 kernels ha^{-1}. The DEKALB hybrid had slightly greater kernel weight (311 mg) compared with the Pioneer hybrid (305 mg).

Grain moisture showed negative linear responses to seeding rates and plant densities in 2011 but did not respond to seeding rates or plant densities in 2012 (Tables 4 and 5). Grain moisture decreased from about 258 g kg^{-1} at the lowest seeding rate to 242 g kg^{-1} at the highest seeding rate in 2011. Stanger and Lauer (2006) also noted a 17 g kg^{-1} decrease in grain moisture as plant densities increased from 64,200 to 123,500 plants ha^{-1}. Although the 16 g kg^{-1} difference in 2011 initially appears small, drying costs differences between the low and high seeding rate at yields around 11.5 Mg ha^{-1} would exceed \$40 ha^{-1}. In 2012, however, grain moisture was much lower (~190 g kg-1) and seeding rate and plant density did not have an effect. Thomison et al. (2011) also noted a decrease in grain moisture from 275 to 261 g kg^{-1} as plant densities increased from 59,000 to 89,000 plants ha^{-1} but no response to plant densities when grain moisture was in the 180 to 200 g kg^{-1} range. Van Roekel and Coulter (2012) also noted no response of grain moisture to plant densities, although moisture values were not reported in that study.

Kernel density showed a negative linear response to seeding rate with no hybrid x seeding rate interaction (Tables 4 and 5). Kernel density decreased from 723 kg m^{-3} at the lowest to 703 kg m^{-3} at the highest seeding rate, which is inconsistent with the Bruns et al. (2012) twin row study that reported no effect of plant density on kernel density. As at Livingston Co., kernel density values exceeded the docking threshold (695 kg m^{-3}) by grain mills for all seeding rates so the negative linear response was of no practical significance. Likewise, % lodging had linear responses to seeding rates (Table 4) but maximum values were only 3.4% at the highest seeding rate, which probably did not affect grain yield. The Pioneer hybrid did have greater lodging (1.9%) compared with the DEKALB hybrid (0.4%), similar to Livingston Co. Unlike the latter, however, the DEKALB hybrid had greater grain moisture in 2011 (256 g kg^{-1}) than the Pioneer hybrid (247 g kg^{-1}).

Partial budget analyses indicate that relative profit showed a quadratic response to seeding rate (Fig. 4) but did not respond to plant density (Table 3), and there were no hybrid x seeding rate or plant density interactions. Maximum relative profit was predicted at about 76,000 kernels ha^{-1}, close to 74,100 kernels ha^{-1} currently recommended in NY (Cox and Cherney, 2012). Nevertheless, the quadratic response of relative profit at this twin row site is not consistent with Van Roekel and Coulter (2012) who reported a lack of response of net returns to plant densities at seed costs ($225/80,000 kernels) and grain prices ($265.76 Mg^{-1}) used in this study. The grower at this site planted all hybrids at 90,155 kernels ha^{-1} in 2011 and 85,215 kernels ha^{-1} in 2012, which indicates that some profit would have been lost in 2011 and 2012. The Pioneer hybrid did have greater profit than the DEKALB hybrid because of its 0.3 Mg ha^{-1} yield advantage.

Seneca Co.-0.76 m Rows

When averaged across years, yield had hybrid x seeding rate and hybrid x plant density interactions (Fig. 1 and Table 3). The Pioneer hybrid showed quadratic responses to seeding rates and plant densities, whereas the DEKALB hybrid had positive linear responses. Maximum predicted yield for the Pioneer hybrid was 70,000 kernels ha^{-1}, somewhat lower than the recommended seeding rate of 74,100 kernels ha^{-1} in New York (Cox and Cherney, 2012). Although the DEKALB hybrid had linear responses to seeding rates, yields differed by only 3.8% from the lowest seeding rate (10.2 Mg ha^{-1}) to the highest seeding rate (10.6 Mg ha^{-1}). The Seneca Co. site had an average yield of 10.4 Mg ha^{-1} so it was expected to have optimum plant densities of about 88,700 plants ha^{-1}, based on the plant density-yield data model of Butzen and Paszkiewicz, (2008). Consequently, the plant density response of the DEKALB hybrid at this site agrees with the

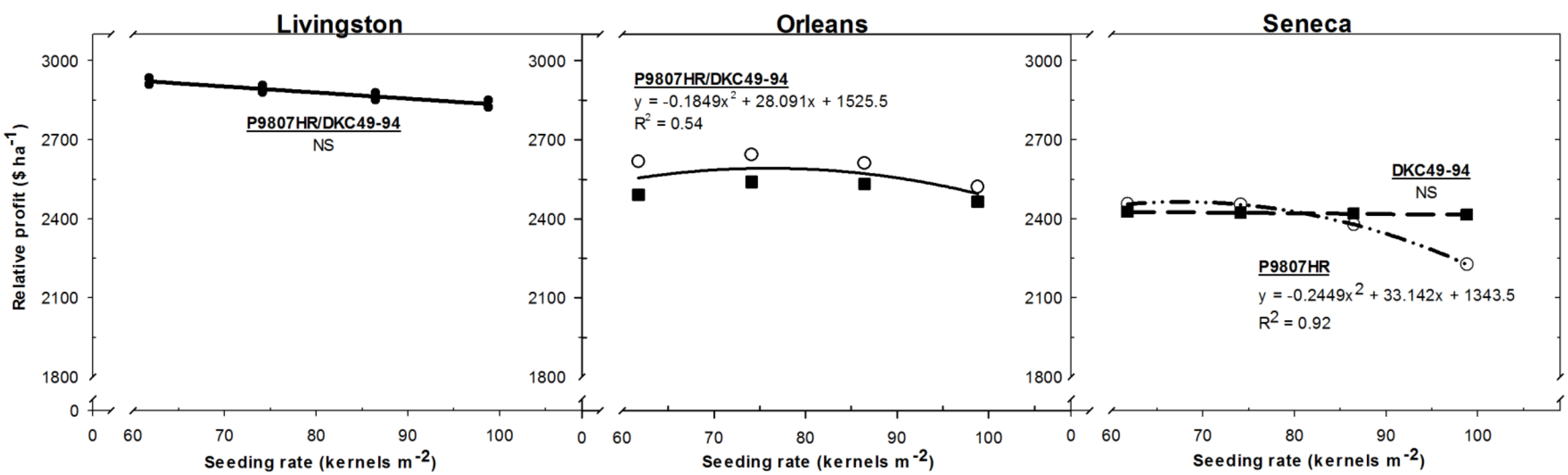

Figure 4. Relationship between relative profit and seeding rate within sites for two corn hybrids (——, combined across hybrids; ○, —··—··, 'P9807HR'; ■, — — —,'DKC49-94').

Butzen and Paszkieqicz (2008) prediction. Nevertheless, yield differences among seeding rates of the DEKALB hybrid were so small that the increase at higher seeding rates may not be economical.

Kernels plant^{-1} had hybrid x seeding rate and hybrid x plant density interactions with both hybrids showing negative linear responses (Fig. 2 and Table 3). The Pioneer hybrid had a 33% decrease from the lowest (536 kernels) to the highest seeding rate (358 kernels), whereas the DEKALB hybrid had a 27% decrease (529 to 383 kernels plant^{-1}, respectively). Despite the interaction, the 27 to 33 % decrease in kernel number plant^{-1} is consistent with the Livingston and Orleans Co. sites. In addition, the approximate 30% decrease in kernels plant^{-1} at these sites is also consistent with small-plot research evaluating different hybrids at similar seeding rates in New York during the dry 2011 growing season.

When averaged across years, kernel weight showed negative linear responses to seeding rates and plant densities with no hybrid interactions (Fig. 3 and Table 3). Kernel weight decreased from 342 mg at the lowest seeding rate to 309 mg at the highest seeding rate, a 9.7% decrease. At this site, the decreases in kernels plant^{-1} and kernel weight did not offset the increase in number of plants ha^{-1}, resulting in maximum yield at >98,800 kernels plant^{-1} for the DEKALB hybrid. Likewise, the predicted maximum yield for the Pioneer hybrid was observed at 95,500 plants ha^{-1} (Table 4), much higher than the seeding rate response, indicating that the decreases in kernels plant^{-1} and kernel weight for the Pioneer hybrid did not offset the increase in plants ha^{-1}. The Pioneer hybrid had slightly greater kernel weight (330 mg) compared with the DEKALB hybrid (322 mg), which is inconsistent with the hybrid effect on kernel weight at the Orleans Co. site.

Grain moisture did not respond to seeding rates or plant densities in 2011 (Tables 4 and 5) but small hybrid differences were observed between the Pioneer (182 g kg^{-1}) and the DEKALB hybrid (175 g kg^{-1}). Grain moisture however, showed hybrid x seeding rate and hybrid x plant density interactions in 2012 (Tables 4 and 5). The DEKALB hybrid showed a negative linear response to seeding rates and plant densities with moistures decreasing from 181 g kg^{-1} at the lowest seeding rate to 171 g kg^{-1} at the highest seeding rate. The Pioneer hybrid also had its highest grain moisture at the lowest seeding rate (185 g kg^{-1}) but then plateaued at about 181 g kg^{-1} at seeding rates from 74,100 to 98,800 kernels ha^{-1}. Grain moisture was less than 190 g kg^{-1} in 2012 so it was not expected that seeding rate would influence grain moisture (Thomison et al., 2011).

Kernel density showed hybrid x seeding rate and plant density interactions with the DEKALB hybrid showing negative linear responses and the Pioneer hybrid showing no response to seeding rate or plant densities (Tables 4 and 5). Kernel density decreased from 739 kg m^{-3} at the lowest seeding rate to 719 kg m^{-3} at the highest seeding rate in the DEKALB hybrid but only ranged from 718 to 722 kg m^{-3} across seeding rates in the Pioneer hybrid. Also, % lodging had linear responses to seeding rates (Table 4), but maximum values were only 0.5% at the highest seeding rate. The Pioneer hybrid once again had greater lodging (0.4%) compared with the DEKALB hybrid (0.1%). Although kernel density and lodging had hybrid and seeding rate effects, values were of insufficient magnitude to be of practical significance.

Partial budget analyses indicate that relative profit had hybrid x seeding rate and hybrid x plant density interactions (Fig. 4 and Table 3). The relative profit of the DEKALB hybrid showed no response to seeding rates or plant densities, whereas the Pioneer hybrid had quadratic responses. Ostensibly, the 3.8% increase in yield of the DEKALB hybrid was not sufficient to offset the \$42.18 ha^{-1} increase in seed costs from the lowest to the highest seeding rate. Maximum relative profit of the Pioneer hybrid was predicted at a seeding rate of 67,665 kernels ha^{-1}, much less than the

74,100 kernels ha^{-1} currently recommended in NY (Cox and Cherney, 2012). The grower at this site seeded at 79,050 kernels ha^{-1} in 2011 and 82,745 kernels ha^{-1} in 2012. The grower would not have lost profit at these seeding rates with the DEKALB hybrid because there was no significant response to seeding rate. The grower, however, would have lost about \$40 ha^{-1} planting the Pioneer hybrid at his seeding rates instead of 67,665 kernels ha^{-1}.

Cayuga Co.-0.51 m Rows

Yield, kernels plant^{-1}, grain moisture, and relative profit did not have homogeneous variances across years so responses of these variables to seeding rates and plant densities have been analyzed for individual years. In 2011, predicted maximum yield occurred at 92,050 kernels ha^{-1} for the Pioneer hybrid and 101,000 kernels ha^{-1} for the DEKALB hybrid (Fig. 5). Predicted maximum yield of the DEKALB hybrid to plant densities, which only averaged 77% of seeding rates at this site in 2011 in part because zone tillage did not result in ideal planting conditions, was 88,642 plants ha^{-1} (Table 3). The yield of the Pioneer hybrid, however, which had 75% plant establishment, showed a linear response to plant density. Yield averaged 11.9 Mg ha^{-1} at this site in 2011 so it was expected to have optimum plant densities of about 92,000 plants ha^{-1} based on the plant density-yield data

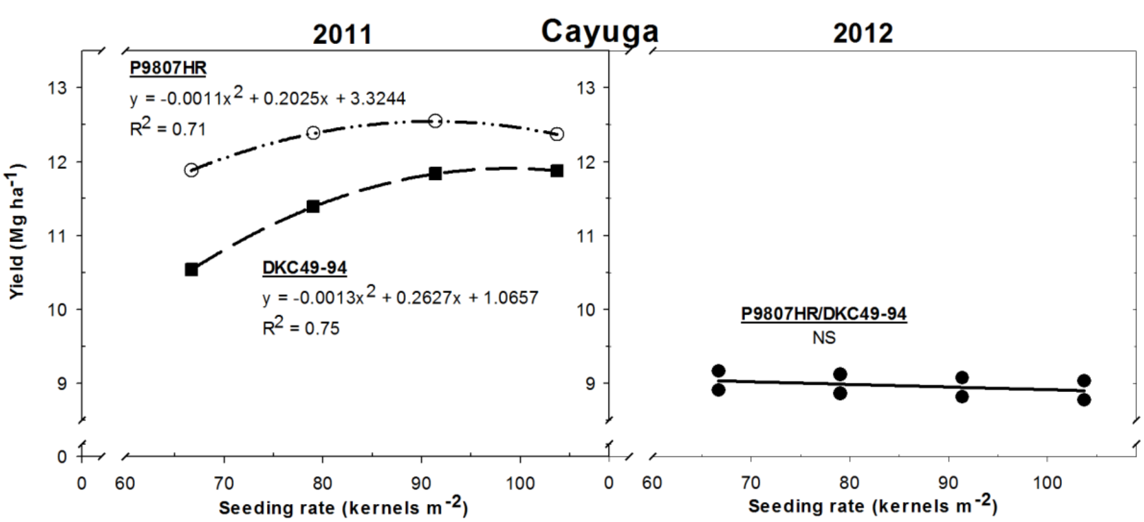

Figure 5. Relationship between grain yield and seeding rate at the Cayuga County sites within years for two corn hybrids (——, combined across hybrids; ○, —··—··—··, 'P9807HR'; ■, — — — —,'DKC49-94').

model of Butzen and Paszkiewicz, (2008). Overall, the results in 2011 mostly agree with the predicted final densities of Butzen and Paszkiewicz, (2008), but exceeded the 84,000 plants ha^{-1} for maximum yield in 0.51 m rows in Minnesota (Van Roekel and Coulter, 2012).

In 2012, however, when plant densities only averaged 75% of seeding rates because of excessive precipitation in late April shortly after planting, yields of both hybrids did not respond to seeding rates and plant densities (Fig. 5 and Table 3). Yields only averaged 8.9 Mg ha^{-1} mostly because the mid-April planting date resulted in both hybrids attaining the R1 stage on 12-13 July when conditions for the previous 2 weeks had been abnormally hot and dry. The results of the 2012 study agree with previous studies in New York that indicated much lower final plant densities are required for maximum yield when conditions are dry for a 2 week period before and during the R1 stage (Cox, 1996; Cox and Cherney, 2012). Both hybrids yielded the same in 2012 (8.8 for the Pioneer and 9.1 Mg ha^{-1} for the DEKALB hybrid) indicating no apparent hybrid differences in drought tolerance.

Kernels $plant^{-1}$ had a hybrid x seeding rate interaction but no hybrid x plant density interaction in 2011 (Fig. 6 and Table 3). The Pioneer hybrid had a 25 % decrease from the lowest (668 kernels) to the highest seeding rate (498 kernels) in 2011, similar to the decrease of the DEKALB hybrid at Seneca Co. Surprisingly, kernels $plant^{-1}$ of the DEKALB hybrid at this site did not respond to seeding rates, perhaps related to its low final plant densities. Nevertheless, kernels $plant^{-1}$ of both hybrids in 2011 showed negative linear responses to plant densities with no hybrid x plant density interaction (Table 3). In 2012, kernels $plant^{-1}$ showed the typical negative linear response when averaged across hybrids with a 35% decrease in kernel number from the lowest (456 kernels $plant^{-1}$) to the highest seeding rate (292 kernels

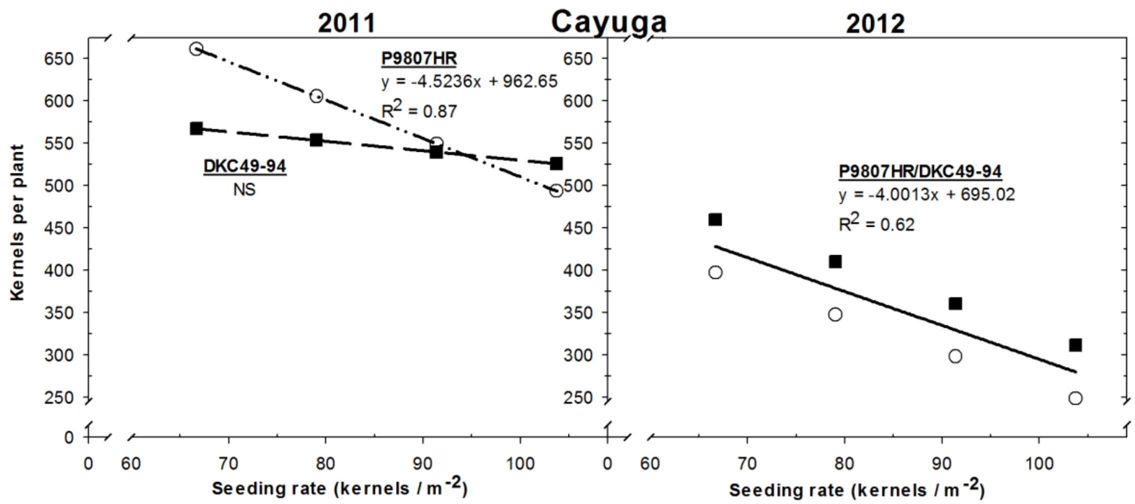

Figure 6. Relationship between kernels per plant and seeding rate at the Cayuga County sites within years for two corn hybrids (——, combined across hybrids; ○, —··—··—··, 'P9807HR'; ■, — — — —,'DKC49-94').

plant^{-1}). The low kernel numbers at this site in 2012 indicate that the warm and dry conditions before and during the R1 stage greatly reduced kernel set. Also, the 35% reduction under stressful conditions is consistent with small-plot research only 10 km south of this site in which there was a 33% reduction in a dry year but only a 15% reduction in a favorable year at the same seeding rates but with two different hybrids. The DEKALB hybrid had more kernels plant^{-1} (385) compared with the Pioneer hybrid (323), which is inconsistent with the results at Livingston and Orleans Co., perhaps because of better kernel set of the DEKALB hybrid under stressful conditions.

When averaged across years, kernel weight showed the typical negative linear response to seeding rates and plant densities with no hybrid interactions (Fig. 3 and Table 3). Kernel weight decreased from 357 mg at the lowest seeding rate to 336 mg at the highest seeding rate, a 5.9% decrease, which was somewhat less than at the other sites. Conditions were favorable during the kernel-fill period in both years at this site, which probably reduced competition for assimilates in the developing kernels, especially in 2012 when kernel numbers were low. When averaged across years, the Pioneer hybrid had greater kernel weight (353 mg) compared with the DEKALB hybrid (341 mg), which is consistent with the hybrid effect on kernel weight at Seneca Co. but inconsistent with results at the Orleans Co. site. The Pioneer hybrid may have had greater kernel weight at this site because of lower kernel numbers.

Grain moisture had hybrid x seeding rate and hybrid x plant density interactions in 2011 (Tables 4 and 5). The Pioneer hybrid had consistent grain moisture across seeding rates (~200 g kg^{-1}) but the DEKALB hybrid showed a negative linear response (196 to 188 g kg^{-1} from the lowest to highest seeding rate). In 2012, grain moisture did not respond to seeding rates (~200 g kg^{-1}) but small differences were observed between the Pioneer (195 g kg^{-1}) and the DEKALB hybrids (203 g kg^{-1}), in contrast to the Seneca Co. site in 2011 where the Pioneer hybrid had 8 g kg^{-1} higher grain moisture at harvest

Kernel density did not respond to seeding rate or plant density (Tables 4 and 5). The Pioneer hybrid did have greater kernel density (723 kg m^{-3}) compared with the DEKALB hybrid (704 kg m^{-3}) but the difference was of not of practical significance because values exceeded the dockage threshold (695 kg m^{-3}). Also, % lodging had linear responses to seeding rates (not plant densities) but maximum values were only about 0.9% at the two higher seeding rates (Tables 4 and 5). The Pioneer hybrid once again had greater lodging (1.0%) compared with the DEKALB hybrid (0.5%), but lodging probably did not affect grain yield at this site.

Partial budget analyses indicated that relative profit had hybrid x seeding rate and hybrid x plant density interactions in 2011 (Fig. 7 and Table 3). Relative profit of both hybrids showed quadratic responses to seeding rates in 2011 with predicted maximum profit for the Pioneer hybrid at 85,100 kernels ha^{-1} and for the DEKALB hybrid at 95,450 kernels ha^{-1}. The relative profit of the Pioneer hybrid, however, showed no response to plant densities, whereas the DEKALB hybrid had a quadratic response with

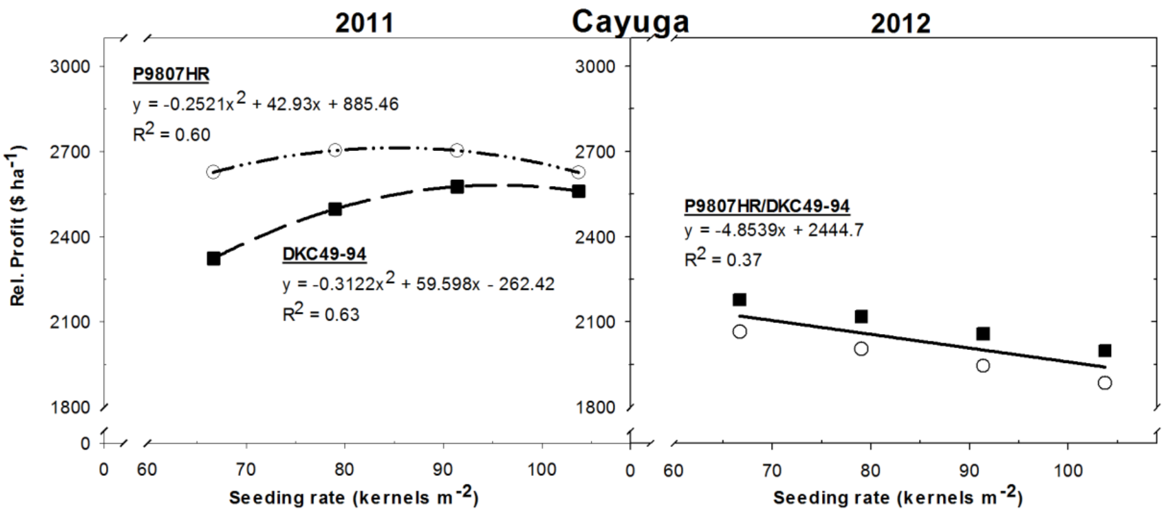

Figure 7. Relationship between relative profit and seeding rate at the Cayuga County sites within years for two corn hybrids (——, combined across hybrids; ○ , —··—··—·· , 'P9807HR'; ■ , — — — —,'DKC49-94').

maximum profit predicted at only 67,000 plants ha^{-1}. Again, final stands were only 75 to 77% for both hybrids in 2011, which contributed to the much lower plant density compared to the seeding rate for maximum profit. In 2012, relative profit showed a negative linear response to seeding rates with no response to plant density. Relative profit declined from about $2160 ha^{-1} to $1964 ha^{-1} as seeding rates increased from 66,690 to 103,740 kernels ha^{-1}. The grower at this site planted all hybrids at 91,000 kernels ha^{-1}, which indicates that profit would have been lost in both years with the DEKALB hybrid. The grower would have lost profit on the Pioneer hybrid only in 2012 because the relative did not respond to seeding rates in 2011. The DEKALB compared to the Pioneer hybrid did have a greater relative profit at this site, presumably due to better drought tolerance.

CONCLUSIONS

Grain yield and relative profit responded inconsistently to seeding rates across sites, between hybrids, and between years at any location. Overall, maximum predicted relative profit never exceeded the recommended seeding rate of 74,100 kernels ha^{-1} (Cox and Cherney, 2012) at the 0.76 m row sites, by only 1900 kernels ha^{-1} at the twin-row site, and by 11,500 to 21,500 kernels ha^{-1} in only 1 of 2 years at the narrow row (0.51 rows) site. Based on the results of this study, recommended seeding rates in New York will not change. Nevertheless, due to inconsistent responses across sites, between hybrids, and between years at the narrow row site, we recommend that growers test the response of new hybrids to seeding rates on different fields to determine optimum seeding rates. Growers can now easily conduct replicated strip-tests on new hybrids at different seeding rates because of the ease in varying seeding rates and the prevalence of yield monitors with modern planting and harvesting equipment. The results of seeding rate studies by growers could also lead to implementation of variable seeding rates within fields.

The lack of a consistent response to seeding rates in this study is probably related to dry conditions before or during the R1 stage at most sites in both years. Consequently, kernels $plant^{-1}$, determined by genetics and environmental conditions during the 10 day period bracketing the R1 stage (Andrade et al., 1999; Echarte et al., 2004), showed a consistent decrease of 4 to 5 kernels $plant^{-1}$ with each 1000 kernel ha^{-1} increase in seeding rate. This resulted in mostly a 25 to 35% decrease in kernels $plant^{-1}$ for both hybrids from the highest to lowest seeding rates at most sites. A previous study in New York (Cox and Cherney, 2012) indicated only a 15% decrease at these seeding rates under more favorable environmental conditions around the R1 stage. Consequently, dry conditions before and during the R1 stage in both years probably biased the results of this study against higher seeding rates because corn is more susceptible to reduced kernel set at high seeding rates under droughty conditions at this critical growth stage (Andrade et al., 1999). On the other hand, dry conditions for a 2 to 3 week period prior to the R1 stage greatly reduced the stature of corn in both years, which in turn greatly reduced the lodging potential at all sites. Consequently, the dry conditions for 2 to 3 weeks before the R1 stage probably also biased the results in favor of higher seeding rates because corn is more susceptible to lodging and resultant yield losses at higher seeding rates.

Although of no practical significance in this study, grain moisture and kernel density often showed negative linear responses to seeding rates. Consequently, higher seeding rates may reduce drying costs, but may also reduce kernel density in some situations. The response of both variables to seeding rates should be studied in more depth because both could influence the relative profit of corn across different seeding rates.

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APPENDIX

Livingston ONLY - SI Units - Fit Least Squares

Response Yield (MG / ha) Farm / Location=Livingston

Summary of Fit

RSquare	0.618564
RSquare Adj	0.601611
Root Mean Square Error	0.613493
Mean of Response	12.56692
Observations (or Sum Wgts)	48

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	12.457717	0.606744	34.91	20.53	<.0001 *
AdjTargetPop(plants/m2)	0.0013603	0.006413	40	0.21	0.8331
Hybrid[9807 HR]	-0.0235	0.08855	40	-0.27	0.7921

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[4]	0.613004	0.362617	7.626	1.69	0.1312
Year[1]:Rep[5]	0.8243581	0.362617	7.626	2.27	0.0542
Year[1]:Rep[6]	0.5040931	0.362617	7.626	1.39	0.2037
Year[2]:Rep[16]	-0.424017	0.362617	7.626	-1.17	0.2775
Year[2]:Rep[17]	-0.751096	0.362617	7.626	-2.07	0.0738
Year[2]:Rep[18]	-0.766342	0.362617	7.626	-2.11	0.0692

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	1.5187088	0.5716021	0.3914092	0.2101784	4.2794195	60.297
Residual		0.3763737	0.0841597	0.2536993	0.6161717	39.703
Total		0.9479758	0.3981373	0.4798138	2.6785917	100.000

-2 LogLikelihood = 113.4777376

Note: Total is the sum of the positive variance components.

Total including negative estimates = 0.9479758

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	40	0.0450	0.8331
Hybrid	1	1	40	0.0704	0.7921

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	12.543417	0.33309045
DKC 49-94	12.590417	0.33309045

Orleans ONLY - SI Units - Fit Least Squares

Response Yield (MG / ha) Farm / Location=Orleans

Summary of Fit

RSquare	0.481401
RSquare Adj	0.432011
Root Mean Square Error	0.44781
Mean of Response	11.46374
Observations (or Sum Wgts)	47

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	11.343604	0.415772	41.96	27.28	<.0001 *
AdjTargetPop(plants/m2)	0.0033689	0.004795	37.01	0.70	0.4867
Hybrid[9807 HR]	0.1593793	0.065475	36.98	2.43	0.0199 *
Hybrid[9807 HR]*(AdjTargetPop(plants/m2)-79.8809)	-0.003944	0.004795	37.02	-0.82	0.4160
(AdjTargetPop(plants/m2)-79.8809)*(AdjTargetPop(plants/m2)-79.8809)	-0.00076	0.00043	36.99	-1.77	0.0852

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[1]	-0.128056	0.186796	8.647	-0.69	0.5110
Year[1]:Rep[2]	0.1051071	0.186796	8.647	0.56	0.5879
Year[1]:Rep[3]	0.2310616	0.186796	8.647	1.24	0.2486
Year[2]:Rep[13]	-0.3598	0.186796	8.647	-1.93	0.0875
Year[2]:Rep[14]	-0.248944	0.186796	8.647	-1.33	0.2167
Year[2]:Rep[15]	0.4006301	0.191461	8.92	2.09	0.0662

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	0.5351469	0.107315	0.0849274	0.0353073	1.3154154	34.860
Residual		0.2005338	0.0466634	0.1332437	0.3358184	65.140
Total		0.3078488	0.0937778	0.1832905	0.6219141	100.000

-2 LogLikelihood = 99.687716212

Note: Total is the sum of the positive variance components.

Total including negative estimates = 0.3078488

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	37.01	0.4936	0.4867
Hybrid	1	1	36.98	5.9253	0.0199 *
Hybrid*AdjTargetPop(plants/m2)	1	1	37.02	0.6766	0.4160
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	36.99	3.1278	0.0852

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	11.772094	0.18150453
DKC 49-94	11.453336	0.18115581

Response Yield (MG / ha) Farm / Location=Seneca, Hybrid=9807 HR

Summary of Fit

RSquare	0.899241
RSquare Adj	0.889645
Root Mean Square Error	0.24073
Mean of Response	10.35896
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	11.614135	0.379828	18.11	30.58	<.0001 *
AdjTargetPop(plants/m2)	-0.013367	0.003559	16	-3.76	0.0017 *
(AdjTargetPop(plants/m2)-80.275)*(AdjTargetPop(plants/m2)-80.275)	-0.000955	0.000322	16	-2.97	0.0091 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	-1.060126	0.260856	6.523	-4.06	0.0056 *
Year[1]:Rep[8]	0.6147541	0.260856	6.523	2.36	0.0532
Year[1]:Rep[9]	0.0827531	0.260856	6.523	0.32	0.7610
Year[2]:Rep[19]	0.246501	0.260856	6.523	0.94	0.3783
Year[2]:Rep[20]	-0.097538	0.260856	6.523	-0.37	0.7203
Year[2]:Rep[21]	0.2136555	0.260856	6.523	0.82	0.4416

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	5.8464392	0.3388063	0.2235014	0.1280525	2.2797348	85.394
Residual		0.0579509	0.0204887	0.0321443	0.1342297	14.606
Total		0.3967571	0.2239705	0.1672807	1.8334829	100.000

-2 LogLikelihood = 40.593304116

Note: Total is the sum of the positive variance components.

Total including negative estimates = 0.3967571

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	16	14.1081	0.0017 *
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	16	8.7927	0.0091 *

Seneca ONLY - SI Units - Fit Least Squares

Response Yield (MG / ha) Farm / Location=Seneca, Hybrid=DKC 49-94

Summary of Fit

RSquare	0.679692
RSquare Adj	0.665132
Root Mean Square Error	0.336427
Mean of Response	10.45804
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	9.7526833	0.438832	21.63	22.22	<.0001 *
AdjTargetPop(plants/m2)	0.0087868	0.004974	17	1.77	0.0952

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	-0.312718	0.220648	8.603	-1.42	0.1916
Year[1]:Rep[8]	0.5725726	0.220648	8.603	2.59	0.0300 *
Year[1]:Rep[9]	0.3308761	0.220648	8.603	1.50	0.1695
Year[2]:Rep[19]	0.0121885	0.220648	8.603	0.06	0.9572
Year[2]:Rep[20]	-0.389066	0.220648	8.603	-1.76	0.1132
Year[2]:Rep[21]	-0.213852	0.220648	8.603	-0.97	0.3589

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	1.5085844	0.1707463	0.1262588	0.0592363	1.6327468	60.137
Residual		0.1131831	0.0388215	0.0637313	0.2543715	39.863
Total		0.2839294	0.1292085	0.1372	0.8969386	100.000

-2 LogLikelihood = 35.86141733

Note: Total is the sum of the positive variance components.

Total including negative estimates = 0.2839294

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	17	3.1213	0.0952

Response Yield (Mg/ha) Farm / Location=Cayuga, Year=1

Summary of Fit

RSquare	0.809135
RSquare Adj	0.768952
Root Mean Square Error	0.338061
Mean of Response	11.85325
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	9.9927283	0.441447	17.95	22.64	<.0001 *
AdjTargetPop(plants/m2)	0.0245641	0.004998	17	4.92	0.0001 *
Hybrid[9807 HR]	0.4419167	0.069006	17	6.40	<.0001 *
Hybrid[9807 HR]*(AdjTargetPop(plants/m2)-85.215)	-0.011506	0.004998	17	-2.30	0.0342 *
(AdjTargetPop(plants/m2)-85.215)*(AdjTargetPop(plants/m2)-85.215)	-0.001221	0.000452	17	-2.70	0.0152 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[10]	0.0327334	0.057868	1	0.57	0.6723
Rep[11]	-0.010365	0.057868	1	-0.18	0.8872
Rep[12]	-0.022368	0.057868	1	-0.39	0.7652

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	0.0341994	0.0039085	0.0188424	0.0003415	4.953e+33	3.307
Residual		0.114285	0.0391994	0.0643518	0.2568479	96.693
Total		0.1181935	0.0388263	0.0679558	0.2550033	100.000

-2 LogLikelihood = 49.637023256

Note: Total is the sum of the positive variance components.
Total including negative estimates = 0.1181935

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	17	24.1584	0.0001 *
Hybrid	1	1	17	41.0112	<.0001 *
Hybrid*AdjTargetPop(plants/m2)	1	1	17	5.3005	0.0342 *
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	17	7.2782	0.0152 *

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	12.527875	0.13515551
DKC 49-94	11.644042	0.13515551

Cayuga ONLY - SI Units - Fit Least Squares

Response Yield (Mg/ha) Farm / Location=Cayuga, Year=2

Summary of Fit

RSquare	0.318419
RSquare Adj	0.253506
Root Mean Square Error	0.912977
Mean of Response	8.969542
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	9.2734867	1.216024	20.97	7.63	<.0001 *
AdjTargetPop(plants/m2)	-0.003567	0.013497	19	-0.26	0.7944
Hybrid[9807 HR]	-0.129375	0.186361	19	-0.69	0.4959

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[22]	0.0944993	0.418528	2.089	0.23	0.8415
Rep[23]	-0.572469	0.418528	2.089	-1.37	0.2999
Rep[24]	0.4779697	0.418528	2.089	1.14	0.3674

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	0.43614	0.3635342	0.4689449	0.0786654	121.90216	30.369
Residual		0.8335263	0.2704316	0.4820663	1.7781362	69.631
Total		1.1970604	0.5241749	0.5916284	3.5783271	100.000

-2 LogLikelihood = 73.559458098

Note: Total is the sum of the positive variance components.

Total including negative estimates = 1.1970604

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	19	0.0698	0.7944
Hybrid	1	1	19	0.4819	0.4959

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	8.8401667	0.43662178
DKC 49-94	9.0989167	0.43662178

Livingston ONLY - SI Units - Fit Least Squares

Response Kernels per plant (actual pop) Farm / Location=Livingston

Summary of Fit

RSquare	0.95991
RSquare Adj	0.956181
Root Mean Square Error	20.72765
Mean of Response	507.6042
Observations (or Sum Wgts)	48

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	918.82812	29.77441	11.62	30.86	<.0001 *
AdjTargetPop(plants/m2)	-5.212551	0.216674	38	-24.06	<.0001 *
Hybrid[9807 HR]	9.3541667	2.991778	38	3.13	0.0034 *
(AdjTargetPop(plants/m2)-80.275)*Hybrid[9807 HR]	-0.235493	0.216674	38	-1.09	0.2839
(AdjTargetPop(plants/m2)-80.275)*(AdjTargetPop(plants/m2)-80.275)	0.0378359	0.019615	38	1.93	0.0612

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[4]	42.837418	24.59869	5.618	1.74	0.1356
Year[1]:Rep[5]	75.196176	24.59869	5.618	3.06	0.0243 *
Year[1]:Rep[6]	35.209118	24.59869	5.618	1.43	0.2055
Year[2]:Rep[16]	-50.67078	24.59869	5.618	-2.06	0.0883
Year[2]:Rep[17]	-53.50063	24.59869	5.618	-2.17	0.0756
Year[2]:Rep[18]	-49.0713	24.59869	5.618	-1.99	0.0963

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	7.835173	3366.2669	2163.0149	1296.7851	21099.686	88.682
Residual		429.63531	98.565099	286.94951	713.60248	11.318
Total		3795.9022	2164.6985	1589.4809	17923.197	100.000

-2 LogLikelihood = 443.41599507

Note: Total is the sum of the positive variance components.

Total including negative estimates = 3795.9022

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	38	578.7430	<.0001 *
Hybrid	1	1	38	9.7758	0.0034 *
AdjTargetPop(plants/m2)*Hybrid	1	1	38	1.1812	0.2839
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	38	3.7206	0.0612

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	509.74479	24.350185
DKC 49-94	491.03646	24.350185

Orleans ONLY - SI Units - Fit Least Squares

Response Kernels per plant (actual pop) Farm / Location=Orleans

Summary of Fit

RSquare	0.914275
RSquare Adj	0.910379
Root Mean Square Error	41.58124
Mean of Response	539.5319
Observations (or Sum Wgts)	47

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	1009.715	55.35101	13.57	18.24	<.0001 *
AdjTargetPop(plants/m2)	-5.907652	0.44453	39.01	-13.29	<.0001 *
Hybrid[9807 HR]	11.39681	6.077786	39.01	1.88	0.0683

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[1]	20.479502	44.1035	5.783	0.46	0.6594
Year[1]:Rep[2]	174.46672	44.1035	5.783	3.96	0.0081 *
Year[1]:Rep[3]	43.510208	44.1035	5.783	0.99	0.3633
Year[2]:Rep[13]	-91.36643	44.1035	5.783	-2.07	0.0854
Year[2]:Rep[14]	-77.401	44.1035	5.783	-1.75	0.1316
Year[2]:Rep[15]	-69.68901	44.34238	5.902	-1.57	0.1679

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	6.1344067	10606.385	6846.8861	4072.2383	67301.433	85.983
Residual		1728.9993	391.53007	1160.2133	2850.6369	14.017
Total		12335.384	6855.2681	5255.6571	55186.818	100.000

-2 LogLikelihood = 489.1314205

Note: Total is the sum of the positive variance components.

Total including negative estimates = 12335.384

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	39.01	176.6149	<.0001 *
Hybrid	1	1	39.01	3.5162	0.0683

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	549.20349	42.892927
DKC 49-94	526.40987	42.934102

Response Kernels per plant (actual pop) Farm / Location=Seneca, Hybrid=9807 HR

Summary of Fit

RSquare	0.971106
RSquare Adj	0.969792
Root Mean Square Error	16.86271
Mean of Response	440.9167
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	820.95	30.15441	13.51	27.22	<.0001 *
AdjTargetPop(plants/m2)	-4.734143	0.249287	17	-18.99	<.0001 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	-83.42776	23.55505	5.9	-3.54	0.0125 *
Year[1]:Rep[8]	-0.406965	23.55505	5.9	-0.02	0.9868
Year[1]:Rep[9]	-45.09168	23.55505	5.9	-1.91	0.1049
Year[2]:Rep[19]	38.661643	23.55505	5.9	1.64	0.1527
Year[2]:Rep[20]	45.254471	23.55505	5.9	1.92	0.1039
Year[2]:Rep[21]	45.010292	23.55505	5.9	1.91	0.1054

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	10.486614	2981.8789	1931.0196	1142.2593	19080.912	91.294
Residual		284.35098	97.531582	160.11279	639.05969	8.706
Total		3266.2299	1932.2507	1333.8087	16721.243	100.000

-2 LogLikelihood = 217.14423444

Note: Total is the sum of the positive variance components.

Total including negative estimates = 3266.2299

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	17	360.6477	<.0001 *

Response Kernels per plant (actual pop) Farm / Location=Seneca, Hybrid=DKC 49-94

Summary of Fit

RSquare	0.933531
RSquare Adj	0.93051
Root Mean Square Error	18.6064
Mean of Response	457.25
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	769.68333	24.94101	21.98	30.86	<.0001 *
AdjTargetPop(plants/m2)	-3.892038	0.275065	17	-14.15	<.0001 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	-38.61122	13.58144	8.197	-2.84	0.0212 *
Year[1]:Rep[8]	-8.25789	13.58144	8.197	-0.61	0.5596
Year[1]:Rep[9]	-16.73897	13.58144	8.197	-1.23	0.2519
Year[2]:Rep[19]	24.550485	13.58144	8.197	1.81	0.1074
Year[2]:Rep[20]	21.87225	13.58144	8.197	1.61	0.1451
Year[2]:Rep[21]	17.185339	13.58144	8.197	1.27	0.2405

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	2.0808913	720.40049	511.22265	257.8987	6015.9657	67.542
Residual		346.19804	118.74495	194.93773	778.0568	32.458
Total		1066.5985	518.07217	495.47932	3729.0661	100.000

-2 LogLikelihood = 213.83682579

Note: Total is the sum of the positive variance components.

Total including negative estimates = 1066.5985

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	17	200.2095	<.0001 *

Response Kernels per plant (actual pop) Farm / Location=Cayuga, Hybrid=9807 HR, Year=1

Summary of Fit

RSquare	0.870278
RSquare Adj	0.857306
Root Mean Square Error	34.34245
Mean of Response	577.1667
Observations (or Sum Wgts)	12

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	962.64667	67.27136	9.954	14.31	<.0001 *
AdjTargetPop(plants/m2)	-4.523617	0.717991	8	-6.30	0.0002 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[10]	12.313321	29.2504	2.248	0.42	0.7107
Rep[11]	34.827027	29.2504	2.248	1.19	0.3443
Rep[12]	-47.14035	29.2504	2.248	-1.61	0.2347

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	1.7391577	2051.1698	2350.6484	493.56162	219990.55	63.492
Residual		1179.4042	589.70208	538.09396	4328.6233	36.508
Total		3230.574	2387.3463	1121.3163	30825.303	100.000

-2 LogLikelihood = 113.47469735

Note: Total is the sum of the positive variance components.

Total including negative estimates = 3230.574

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	8	39.6948	0.0002 *

Cayuga ONLY - SI Units - Fit Least Squares

Response Kernels per plant (actual pop) Farm / Location=Cayuga, Hybrid=DKC 49-94, Year=1

Summary of Fit

RSquare	0.206451
RSquare Adj	0.127097
Root Mean Square Error	33.13618
Mean of Response	546.3333
Observations (or Sum Wgts)	12

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	641.55333	59.80446	10	10.73	<.0001 *
AdjTargetPop(plants/m2)	-1.117409	0.692771	10	-1.61	0.1378

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	10	2.6016	0.1378

Cayuga ONLY - SI Units - Fit Least Squares

Response Kernels per plant (actual pop) Farm / Location=Cayuga, Year=2

Summary of Fit

RSquare	0.622069
RSquare Adj	0.586076
Root Mean Square Error	58.6675
Mean of Response	354.0417
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	695.01667	76.38681	20.76	9.10	<.0001 *
AdjTargetPop(plants/m2)	-4.00135	0.867301	19	-4.61	0.0002 *
Hybrid[9807 HR]	-31.29167	11.97545	19	-2.61	0.0171 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[22]	-12.6372	20.14276	1.407	-0.63	0.6167
Rep[23]	23.7364	20.14276	1.407	1.18	0.4004
Rep[24]	-11.0992	20.14276	1.407	-0.55	0.6563

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	0.1998426	687.83333	1126.7474	119.75283	6994470.7	16.656
Residual		3441.875	1116.6917	1990.5934	7342.447	83.344
Total		4129.7083	1484.8603	2271.3195	9732.6431	100.000

-2 LogLikelihood = 247.30929461

Note: Total is the sum of the positive variance components.

Total including negative estimates = 4129.7083

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	19	21.2850	0.0002 *
Hybrid	1	1	19	6.8277	0.0171 *

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	322.75000	22.717850
DKC 49-94	385.33333	22.717850

Livingston ONLY - SI Units - Fit Least Squares

Response Kernel Weight (mg) Farm / Location=Livingston, Hybrid=9807 HR

Summary of Fit

RSquare	0.920971
RSquare Adj	0.913444
Root Mean Square Error	6.215279
Mean of Response	331.0417
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	409.48333	8.844452	20.86	46.30	<.0001 *
AdjTargetPop(plants/m2)	-1.013495	0.091883	16	-11.03	<.0001 *
(AdjTargetPop(plants/m2)-80.275)*(AdjTargetPop(plants/m2)-80.275)	0.0152983	0.008318	16	1.84	0.0845

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[4]	-8.358607	5.209242	7.533	-1.60	0.1496
Rep[5]	-8.127494	5.209242	7.533	-1.56	0.1597
Rep[6]	-11.36308	5.209242	7.533	-2.18	0.0628
Rep[16]	12.441614	5.209242	7.533	2.39	0.0458 *
Rep[17]	9.6682507	5.209242	7.533	1.86	0.1028
Rep[18]	5.7393202	5.209242	7.533	1.10	0.3045

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	3.0592532	118.17799	80.922282	43.454555	884.72964	75.365
Residual		38.629688	13.657657	21.427197	89.476698	24.635
Total		156.80768	81.496512	69.806252	616.31872	100.000

-2 LogLikelihood = 174.08418716

Note: Total is the sum of the positive variance components.

Total including negative estimates = 156.80768

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	16	121.6683	<.0001 *
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	16	3.3825	0.0845

Livingston ONLY - SI Units - Fit Least Squares

Response Kernel Weight (mg) Farm / Location=Livingston, Hybrid=DKC 49-94

Summary of Fit

RSquare	0.986365
RSquare Adj	0.985066
Root Mean Square Error	3.070016
Mean of Response	331.9792
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	382.56979	9.384111	6.971	40.77	<.0001 *
AdjTargetPop(plants/m2)	-0.655196	0.045385	16	-14.44	<.0001 *
(AdjTargetPop(plants/m2)-80.275)*(AdjTargetPop(plants/m2)-80.275)	0.0105176	0.004109	16	2.56	0.0210 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[4]	-17.38663	8.702576	5.21	-2.00	0.0999
Rep[5]	-16.14324	8.702576	5.21	-1.85	0.1204
Rep[6]	-22.85751	8.702576	5.21	-2.63	0.0449 *
Rep[16]	12.827558	8.702576	5.21	1.47	0.1982
Rep[17]	20.536526	8.702576	5.21	2.36	0.0627
Rep[18]	23.02329	8.702576	5.21	2.65	0.0438 *

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	46.969772	442.6901	281.47326	171.83304	2699.5625	97.915
Residual		9.425	3.3322407	5.2278789	21.830823	2.085
Total		452.1151	281.48312	178.14299	2613.8127	100.000

-2 LogLikelihood = 157.75087557

Note: Total is the sum of the positive variance components.

Total including negative estimates = 452.1151

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	16	208.4087	<.0001 *
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	16	6.5528	0.0210 *

Orleans ONLY - SI Units - Fit Least Squares

Response Kernel Weight (mg) Farm / Location=Orleans

Summary of Fit

RSquare	0.888164
RSquare Adj	0.877513
Root Mean Square Error	13.48929
Mean of Response	307.7021
Observations (or Sum Wgts)	47

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	372.02889	18.1188	13.73	20.53	<.0001 *
AdjTargetPop(plants/m2)	-0.871903	0.144451	37.01	-6.04	<.0001 *
Hybrid[9807 HR]	-3.586366	1.972368	37	-1.82	0.0771
(AdjTargetPop(plants/m2)-79.8809)*Hybrid[9807 HR]	-0.199571	0.144452	37.01	-1.38	0.1754
(AdjTargetPop(plants/m2)-79.8809)*(AdjTargetPop(plants/m2)-79.8809)	0.0333177	0.01294	37	2.57	0.0142 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[1]	-30.89505	14.36407	5.772	-2.15	0.0768
Year[1]:Rep[2]	-31.87525	14.36407	5.772	-2.22	0.0700
Year[1]:Rep[3]	-27.70941	14.36407	5.772	-1.93	0.1039
Year[2]:Rep[13]	26.691585	14.36407	5.772	1.86	0.1144
Year[2]:Rep[14]	28.039357	14.36407	5.772	1.95	0.1007
Year[2]:Rep[15]	35.748772	14.4472	5.899	2.47	0.0488 *

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	6.1875222	1125.887	727.02873	432.18129	7149.8993	86.087
Residual		181.96089	42.306263	120.93995	304.56795	13.913
Total		1307.8479	727.9363	556.65754	5869.475	100.000

-2 LogLikelihood = 396.99760042

Note: Total is the sum of the positive variance components.

Total including negative estimates = 1307.8479

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	37.01	36.4332	<.0001 *
Hybrid	1	1	37	3.3062	0.0771
AdjTargetPop(plants/m2)*Hybrid	1	1	37.01	1.9087	0.1754
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	37	6.6300	0.0142 *

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	298.79419	14.188435
DKC 49-94	305.96693	14.184380

Seneca ONLY - SI Units - Fit Least Squares

Response Kernel Weight (mg) Farm / Location=Seneca

Summary of Fit

RSquare	0.833492
RSquare Adj	0.826091
Root Mean Square Error	10.81398
Mean of Response	325.4583
Observations (or Sum Wgts)	48

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	401.61667	11.95732	22.59	33.59	<.0001 *
AdjTargetPop(plants/m2)	-0.948718	0.113043	40	-8.39	<.0001 *
Hybrid[9807 HR]	4	1.560863	40	2.56	0.0143 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	17.436687	8.35982	6.52	2.09	0.0784
Year[1]:Rep[8]	1.7196733	8.35982	6.52	0.21	0.8433
Year[1]:Rep[9]	23.435547	8.35982	6.52	2.80	0.0284 *
Year[2]:Rep[19]	-2.479529	8.35982	6.52	-0.30	0.7760
Year[2]:Rep[20]	-22.15579	8.35982	6.52	-2.65	0.0352 *
Year[2]:Rep[21]	-17.95659	8.35982	6.52	-2.15	0.0717

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	2.985817	349.16766	230.10132	132.06711	2342.8355	74.911
Residual		116.94208	26.149045	78.826235	191.4491	25.089
Total		466.10974	231.21299	213.71826	1687.7227	100.000

-2 LogLikelihood = 374.91570722

Note: Total is the sum of the positive variance components.

Total including negative estimates = 466.10974

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	40	70.4350	<.0001 *
Hybrid	1	1	40	6.5674	0.0143 *

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	329.45833	7.9414858
DKC 49-94	321.45833	7.9414858

Cayuga ONLY - SI Units - Fit Least Squares

Response Kernel Weight (mg) Farm / Location=Cayuga

Summary of Fit

RSquare	0.691225
RSquare Adj	0.677501
Root Mean Square Error	12.23756
Mean of Response	347.1563
Observations (or Sum Wgts)	48

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	390.1375	12.58875	37.63	30.99	<.0001 *
AdjTargetPop(plants/m2)	-0.504386	0.127924	40	-3.94	0.0003 *
Hybrid[9807 HR]	6.0520833	1.766339	40	3.43	0.0014 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[10]	-11.48746	7.134129	7.696	-1.61	0.1475
Year[1]:Rep[11]	-14.82717	7.134129	7.696	-2.08	0.0727
Year[1]:Rep[12]	-12.17844	7.134129	7.696	-1.71	0.1277
Year[2]:Rep[22]	16.03638	7.134129	7.696	2.25	0.0560
Year[2]:Rep[23]	11.084392	7.134129	7.696	1.55	0.1603
Year[2]:Rep[24]	11.372298	7.134129	7.696	1.59	0.1511

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	1.4633119	219.14238	150.49543	80.405116	1654.8401	59.404
Residual		149.75781	33.486865	100.94608	245.17263	40.596
Total		368.9002	153.26416	187.85519	1027.8258	100.000

-2 LogLikelihood = 382.68496631

Note: Total is the sum of the positive variance components.

Total including negative estimates = 368.9002

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	40	15.5461	0.0003 *
Hybrid	1	1	40	11.7398	0.0014 *

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	353.20833	6.5393914
DKC 49-94	341.10417	6.5393914

Livingston ONLY - SI Units - Fit Least Squares

Response Profit Combined Years (SI) Farm / Location=Livingston

Summary of Fit

RSquare	0.514843
RSquare Adj	0.49328
Root Mean Square Error	150.0058
Mean of Response	2878.576
Observations (or Sum Wgts)	48

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	3063.8014	140.3843	41.94	21.82	<.0001 *
AdjTargetPop(plants/m2)	-2.307381	1.56807	40	-1.47	0.1490
Hybrid[9807 HR]	-12.49624	21.65147	40	-0.58	0.5671

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[4]	106.18288	73.8476	8.54	1.44	0.1861
Year[1]:Rep[5]	151.59492	73.8476	8.54	2.05	0.0720
Year[1]:Rep[6]	96.660944	73.8476	8.54	1.31	0.2247
Year[2]:Rep[16]	-66.7674	73.8476	8.54	-0.90	0.3907
Year[2]:Rep[17]	-140.0529	73.8476	8.54	-1.90	0.0922
Year[2]:Rep[18]	-147.6185	73.8476	8.54	-2.00	0.0784

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	0.9049963	20363.979	14671.716	7206.8413	178536.04	47.506
Residual		22501.726	5031.5389	15167.562	36838.194	52.494
Total		42865.705	15305.114	23659.536	100293.32	100.000

-2 LogLikelihood = 606.07413882

Note: Total is the sum of the positive variance components.

Total including negative estimates = 42865.705

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	40	2.1652	0.1490
Hybrid	1	1	40	0.3331	0.5671

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	2866.0801	65.814652
DKC 49-94	2891.0726	65.814652

Orleans ONLY - SI Units - Fit Least Squares

Response Profit Combined Years (SI) Farm / Location=Orleans

Summary of Fit

RSquare	0.540516
RSquare Adj	0.496756
Root Mean Square Error	115.3026
Mean of Response	2551.277
Observations (or Sum Wgts)	47

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2710.2137	108.7235	41.45	24.93	<.0001 *
AdjTargetPop(plants/m2)	-1.508319	1.23468	36.92	-1.22	0.2296
Hybrid[9807 HR]	45.817775	16.8589	36.89	2.72	0.0100 *
(AdjTargetPop(plants/m2)-79.8809)*Hybrid[9807 HR]	-0.950127	1.234691	36.92	-0.77	0.4465
(AdjTargetPop(plants/m2)-79.8809)*(AdjTargetPop(plants/m2)-79.8809)	-0.189037	0.110601	36.89	-1.71	0.0958

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[1]	-75.82826	52.20559	8.534	-1.45	0.1821
Year[1]:Rep[2]	-45.22192	52.20559	8.534	-0.87	0.4101
Year[1]:Rep[3]	-39.36031	52.20559	8.534	-0.75	0.4712
Year[2]:Rep[13]	-19.69699	52.20559	8.534	-0.38	0.7152
Year[2]:Rep[14]	8.7804891	52.20559	8.534	0.17	0.8704
Year[2]:Rep[15]	171.327	53.42351	8.904	3.21	0.0109 *

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	0.6975642	9273.8968	7062.8235	3144.6671	98385.472	41.092
Residual		13294.687	3097.161	8829.885	22278.447	58.908
Total		22568.583	7519.5281	12888.288	49335.267	100.000

-2 LogLikelihood = 567.06199703

Note: Total is the sum of the positive variance components.

Total including negative estimates = 22568.583

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	36.92	1.4924	0.2296
Hybrid	1	1	36.89	7.3860	0.0100 *
AdjTargetPop(plants/m2)*Hybrid	1	1	36.92	0.5922	0.4465
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	36.89	2.9213	0.0958

Effect Details

AdjTargetPop(plants/m2)

Hybrid

Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	2635.5456	50.437670
DKC 49-94	2543.9101	50.354398

Seneca ONLY - SI Units - Fit Least Squares

Response Profit Combined Years (SI) Farm / Location=Seneca, Hybrid=9807 HR

Summary of Fit

RSquare	0.915775
RSquare Adj	0.907754
Root Mean Square Error	61.13383
Mean of Response	2379.164
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2921.5606	96.27258	18.18	30.35	<.0001 *
AdjTargetPop(plants/m2)	-6.175118	0.903762	16	-6.83	<.0001 *
(AdjTargetPop(plants/m2)-80.275)*(AdjTargetPop(plants/m2)-80.275)	-0.24489	0.081817	16	-2.99	0.0086 *

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	-269.0129	65.97214	6.536	-4.08	0.0054 *
Year[1]:Rep[8]	157.15131	65.97214	6.536	2.38	0.0512
Year[1]:Rep[9]	22.562664	65.97214	6.536	0.34	0.7431
Year[2]:Rep[19]	51.496063	65.97214	6.536	0.78	0.4624
Year[2]:Rep[20]	-18.24724	65.97214	6.536	-0.28	0.7906
Year[2]:Rep[21]	56.050084	65.97214	6.536	0.85	0.4256

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	5.789042	21635.649	14278.334	8174.7815	145746.06	85.270
Residual		3737.3454	1321.3511	2073.0386	8656.6925	14.730
Total		25372.995	14308.872	10704.929	117008.45	100.000

-2 LogLikelihood = 273.10610639

Note: Total is the sum of the positive variance components.
Total including negative estimates = 25372.995

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	16	46.6855	<.0001 *
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	16	8.9590	0.0086 *

Seneca ONLY - SI Units - Fit Least Squares

Response Profit Combined Years (SI) Farm / Location=Seneca, Hybrid=DKC 49-94

Summary of Fit

RSquare	0.682526
RSquare Adj	0.668095
Root Mean Square Error	80.65247
Mean of Response	2421.384
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2445.0521	106.0639	21.79	23.05	<.0001 *
AdjTargetPop(plants/m2)	-0.294836	1.192313	17	-0.25	0.8077

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Year[1]:Rep[7]	-77.60293	54.74379	8.496	-1.42	0.1919
Year[1]:Rep[8]	154.33758	54.74379	8.496	2.82	0.0212 *
Year[1]:Rep[9]	78.648483	54.74379	8.496	1.44	0.1866
Year[2]:Rep[19]	-12.19006	54.74379	8.496	-0.22	0.8290
Year[2]:Rep[20]	-94.20839	54.74379	8.496	-1.72	0.1214
Year[2]:Rep[21]	-48.98468	54.74379	8.496	-0.89	0.3955

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep[Year]	1.6765128	10905.416	7945.2966	3826.6959	99190.241	62.638
Residual		6504.8213	2231.1353	3662.7448	14619.148	37.362
Total		17410.237	8100.4148	8302.4616	56862.272	100.000

-2 LogLikelihood = 277.41646442

Note: Total is the sum of the positive variance components.
Total including negative estimates = 17410.237

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	17	0.0611	0.8077

Cayuga ONLY - SI Units - Fit Least Squares

Response 2011 Profit (SI) Farm / Location=Cayuga, Hybrid=9807 HR, Year=1

Summary of Fit

RSquare	0.601116
RSquare Adj	0.512475
Root Mean Square Error	67.69805
Mean of Response	2664.919
Observations (or Sum Wgts)	12

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2716.2412	129.0713	8.185	21.04	<.0001 *
AdjTargetPop(plants/m2)	-0.038199	1.415349	7	-0.03	0.9792
(AdjTargetPop(plants/m2)-85.215)*(AdjTargetPop(plants/m2)-85.215)	-0.252119	0.12813	7	-1.97	0.0898

Random Effect Predictions

Term	BLUP	Std Error	DFDen	t Ratio	Prob>|t|
Rep[10]	43.977174	41.29933	1.993	1.06	0.3988
Rep[11]	11.102238	41.29933	1.993	0.27	0.8133
Rep[12]	-55.07941	41.29933	1.993	-1.33	0.3143

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Rep	0.7424424	3402.6326	4589.4354	707.1206	1902257.2	42.609
Residual		4583.0258	2449.7304	2003.4755	18984.417	57.391
Total		7985.6585	4905.4568	3176.5381	44666.852	100.000

-2 LogLikelihood = 126.92914206

Note: Total is the sum of the positive variance components.
Total including negative estimates = 7985.6585

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	7	0.0007	0.9792
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	7	3.8717	0.0898

Cayuga ONLY - SI Units - Fit Least Squares

Response 2011 Profit (SI) Farm / Location=Cayuga, Hybrid=DKC 49-94, Year=1

Summary of Fit

RSquare	0.631802
RSquare Adj	0.54998
Root Mean Square Error	88.35675
Mean of Response	2489.564
Observations (or Sum Wgts)	12

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2004.7504	162.623	9	12.33	<.0001 *
AdjTargetPop(plants/m2)	6.3878252	1.847256	9	3.46	0.0072 *
(AdjTargetPop(plants/m2)-85.215)*(AdjTargetPop(plants/m2)-85.215)	-0.312213	0.16723	9	-1.87	0.0948

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	9	11.9578	0.0072 *
AdjTargetPop(plants/m2)*AdjTargetPop(plants/m2)	1	1	9	3.4856	0.0948

Cayuga ONLY - SI Units - Fit Least Squares

Response 2012 (SI) Farm / Location=Cayuga, Year=2

Summary of Fit

RSquare	0.370094
RSquare Adj	0.310103
Root Mean Square Error	122.2976
Mean of Response	2031.115
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	DFDen	t Ratio	Prob>|t|
Intercept	2444.7408	156.0752	21	15.66	<.0001 *
AdjTargetPop(plants/m2)	-4.853908	1.807966	21	-2.68	0.0139 *
Hybrid[9807 HR]	-56.54472	24.96389	21	-2.27	0.0342 *

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
AdjTargetPop(plants/m2)	1	1	21	7.2078	0.0139 *
Hybrid	1	1	21	5.1305	0.0342 *

Effect Details

AdjTargetPop(plants/m2)

Hybrid

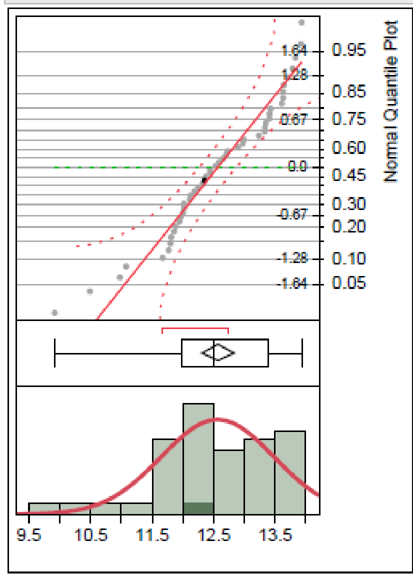
Least Squares Means Table

Level	Least Sq Mean	Std Error
9807 HR	1974.5703	35.304276
DKC 49-94	2087.6597	35.304276

2011-2012 JMP format - SI Units - Distribution

Distributions Farm / Location=Livingston

Yield (Mg/ha)



Normal(12.5669,0.92073)

Quantiles

100.0%	maximum	13.937
99.5%		13.937
97.5%		13.935
90.0%		13.7273
75.0%	quartile	13.3983
50.0%	median	12.4925
25.0%	quartile	11.98
10.0%		11.6107
2.5%		10.0426
0.5%		9.913
0.0%	minimum	9.913

Summary Statistics

Mean	12.566917
Std Dev	0.9207345
Std Err Mean	0.1328966
Upper 95% Mean	12.83427
Lower 95% Mean	12.299563
N	48

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	12.566917	12.299563	12.83427
Dispersion	σ	0.9207345	0.7664827	1.1532939

-2log(Likelihood) = 127.290073714642

Goodness-of-Fit Test

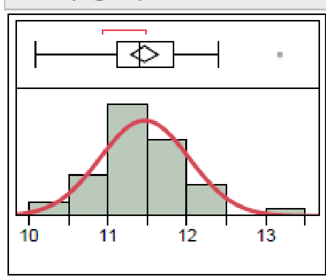
Shapiro-Wilk W Test

W	Prob<W
0.949549	0.0384 *

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Orleans

Yield (Mg/ha)



Normal(11.4637,0.56494)

Quantiles

100.0%	maximum	13.181
99.5%		13.181
97.5%		13.022
90.0%		12.318
75.0%	quartile	11.825
50.0%	median	11.397
25.0%	quartile	11.104
10.0%		10.9198
2.5%		10.1114
0.5%		10.09
0.0%	minimum	10.09

Summary Statistics

Mean	11.463745
Std Dev	0.5649423
Std Err Mean	0.0824053
Upper 95% Mean	11.629618
Lower 95% Mean	11.297871
N	47

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	11.463745	11.297871	11.629618
Dispersion	σ	0.5649423	0.4694529	0.7095595

-2log(Likelihood) = 78.7032381786872

Goodness-of-Fit Test

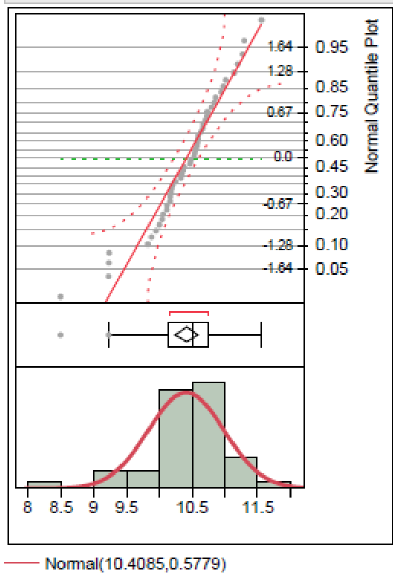
Shapiro-Wilk W Test

W	Prob<W
0.968655	0.2353

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Seneca

Yield (Mg/ha)



Quantiles

100.0%	maximum	11.557
99.5%		11.557
97.5%		11.4974
90.0%		11.1441
75.0%	quartile	10.7298
50.0%	median	10.5035
25.0%	quartile	10.1298
10.0%		9.7651
2.5%		8.66025
0.5%		8.496
0.0%	minimum	8.496

Summary Statistics

Mean	10.4085
Std Dev	0.5778952
Std Err Mean	0.083412
Upper 95% Mean	10.576303
Lower 95% Mean	10.240697
N	48

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	10.4085	10.240697	10.576303
Dispersion	σ	0.5778952	0.4810797	0.7238601

-2log(Likelihood) = 82.5752682770857

Goodness-of-Fit Test

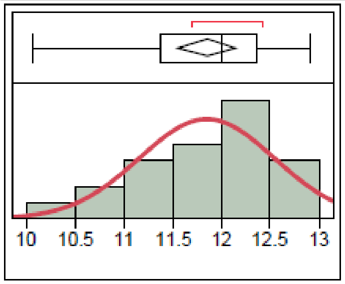
Shapiro-Wilk W Test

W	Prob<W
0.944730	0.0248 *

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Cayuga, Year=1

Yield (Mg/ha)



Quantiles

100.0%	maximum	12.916
99.5%		12.916
97.5%		12.916
90.0%		12.719
75.0%	quartile	12.3698
50.0%	median	12.001
25.0%	quartile	11.3733
10.0%		10.8965
2.5%		10.073
0.5%		10.073
0.0%	minimum	10.073

Summary Statistics

Mean	11.85325
Std Dev	0.695308
Std Err Mean	0.1419292
Upper 95% Mean	12.146853
Lower 95% Mean	11.559647
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	11.85325	11.559647	12.146853
Dispersion	σ	0.695308	0.5404028	0.9753507

-2log(Likelihood) = 49.6658332247899

Goodness-of-Fit Test

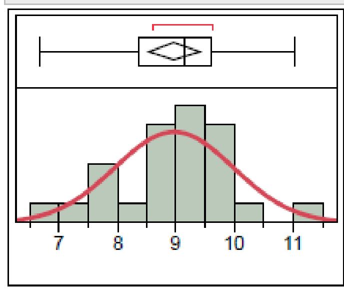
Shapiro-Wilk W Test

W	Prob<W
0.952371	0.3047

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Cayuga, Year=2

Yield (Mg/ha)



Quantiles

100.0%	maximum	11.02
99.5%		11.02
97.5%		11.02
90.0%		10.14
75.0%	quartile	9.6025
50.0%	median	9.139
25.0%	quartile	8.38625
10.0%		7.432
2.5%		6.666
0.5%		6.666
0.0%	minimum	6.666

Summary Statistics

Mean	8.9695417
Std Dev	1.0168263
Std Err Mean	0.2075588
Upper 95% Mean	9.3989097
Lower 95% Mean	8.5401736
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	8.9695417	8.5401736	9.3989097
Dispersion	σ	1.0168263	0.7902912	1.4263638

-2log(Likelihood) = 67.9099905648041

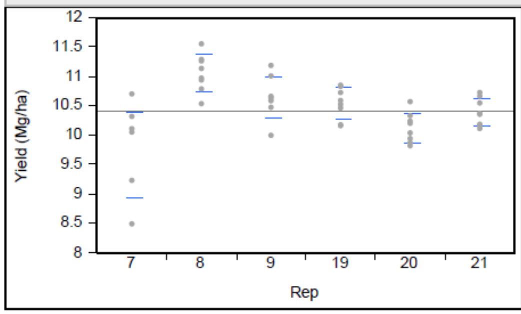
Goodness-of-Fit Test

Shapiro-Wilk W Test

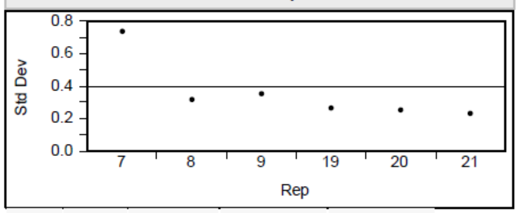
W	Prob<W
0.974526	0.7779

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Oneway Analysis of Yield (Mg/ha) By Rep Farm / Location=Senec



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
7	8	0.7373348	0.6267500	0.6267500
8	8	0.3192311	0.2507500	0.2507500
9	8	0.3548348	0.2333750	0.2312500
19	8	0.2670208	0.2088750	0.2088750
20	8	0.2554041	0.2083750	0.2083750
21	8	0.2340041	0.1910625	0.1865000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	4.0838	5	42	0.0041 *
Brown-Forsythe	5.5753	5	42	0.0005 *
Levene	5.6791	5	42	0.0004 *
Bartlett	3.0009	5	.	0.0103 *

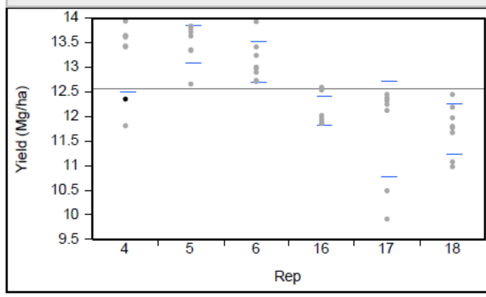
Welch's Test

Welch Anova testing Means Equal, allowing Std Devs Not Equal

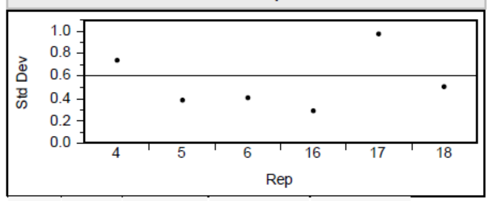
F Ratio	DFNum	DFDen	Prob > F
9.5635	5	19.419	0.0001 *

2011-2012 JMP format - SI Units - Oneway

Oneway Analysis of Yield (Mg/ha) By Rep Farm / Location=Livingston



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
4	8	0.7411776	0.5744375	0.4776250
5	8	0.3843568	0.2871250	0.2871250
6	8	0.4062817	0.3108750	0.2830000
16	8	0.2890576	0.2287500	0.1840000
17	8	0.9776346	0.7765000	0.5947500
18	8	0.5054206	0.3723750	0.3640000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.8488	5	42	0.1241
Brown-Forsythe	0.7310	5	42	0.6042
Levene	3.1513	5	42	0.0167 *
Bartlett	2.7409	5	.	0.0176 *

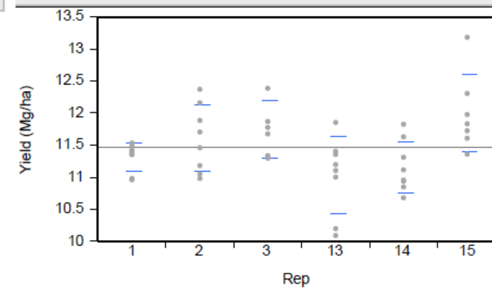
Welch's Test

Welch Anova testing Means Equal, allowing Std Devs Not Equal

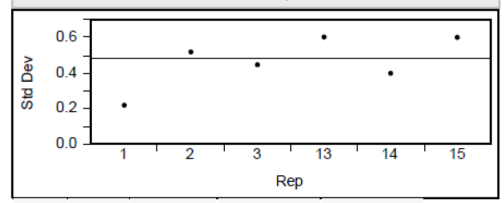
F Ratio	DFNum	DFDen	Prob > F
19.4879	5	19.233	<.0001 *

11-2012 JMP format - SI Units - Oneway

Oneway Analysis of Yield (Mg/ha) By Rep Farm / Location=Orleans



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
1	8	0.2190763	0.1705625	0.1481250
2	8	0.5183200	0.4310000	0.4310000
3	8	0.4459024	0.3488750	0.3488750
13	8	0.6018545	0.4466875	0.4270000
14	8	0.3979182	0.3195000	0.3075000
15	7	0.5996780	0.4257143	0.4117143

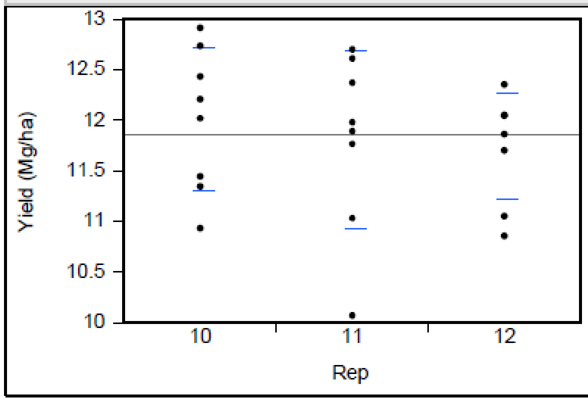
Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.9776	5	41	0.4429
Brown-Forsythe	0.9849	5	41	0.4387
Levene	1.1640	5	41	0.3432
Bartlett	1.4315	5	.	0.2092

Welch's Test

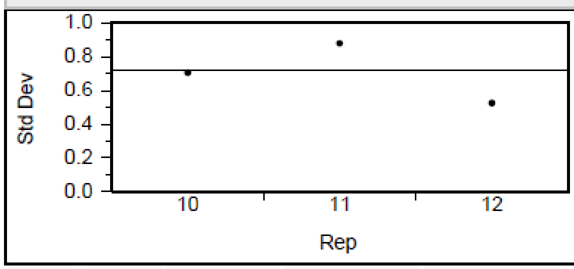
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
3.5666	5	18.313	0.0200 *

Oneway Analysis of Yield (Mg/ha) By Rep Farm / Location=Cayuga, Year=1



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
10	8	0.7050886	0.5719688	0.5681250
11	8	0.8797225	0.6350000	0.6127500
12	8	0.5252057	0.4073438	0.3781250

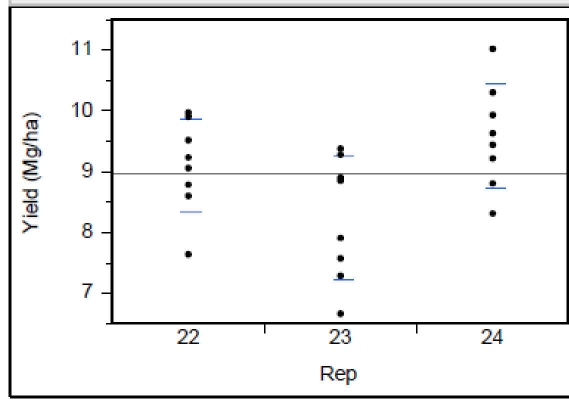
Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.8015	2	21	0.4619
Brown-Forsythe	0.5578	2	21	0.5807
Levene	0.6346	2	21	0.5400
Bartlett	0.8426	2	.	0.4306

Welch's Test

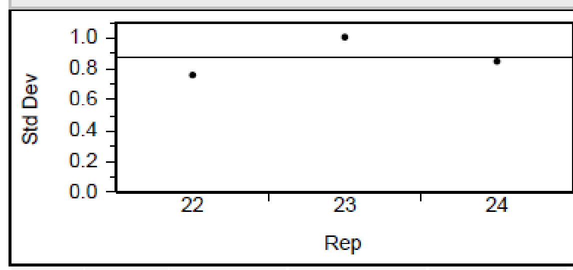
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
0.3294	2	13.402	0.7250

Oneway Analysis of Yield (Mg/ha) By Rep Farm / Location=Cayuga, Year=2



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
22	8	0.763391	0.5678750	0.5678750
23	8	1.009934	0.8727500	0.8727500
24	8	0.851704	0.6382500	0.6382500

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.4647	2	21	0.6347
Brown-Forsythe	0.9328	2	21	0.4092
Levene	0.9808	2	21	0.3915
Bartlett	0.2652	2	.	0.7670

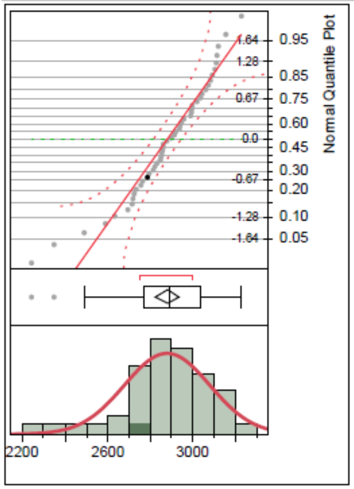
Welch's Test

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
4.0113	2	13.831	0.0423 *

Distributions Farm / Location=Livingston

Rel. Profit (2011-2012)



Normal(2878.58,200.178)

Quantiles

100.0%	maximum	3227.5
99.5%		3227.5
97.5%		3211.01
90.0%		3109.74
75.0%	quartile	3030.99
50.0%	median	2887.93
25.0%	quartile	2769.37
10.0%		2629.07
2.5%		2266.55
0.5%		2242.68
0.0%	minimum	2242.68

Summary Statistics

Mean	2878.5763
Std Dev	200.17833
Std Err Mean	28.893254
Upper 95% Mean	2936.7021
Lower 95% Mean	2820.4506
N	48

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2878.5763	2820.4506	2936.7021
Dispersion	σ	200.17833	166.64222	250.73945

-2log(Likelihood) = 643.942128515852

Goodness-of-Fit Test

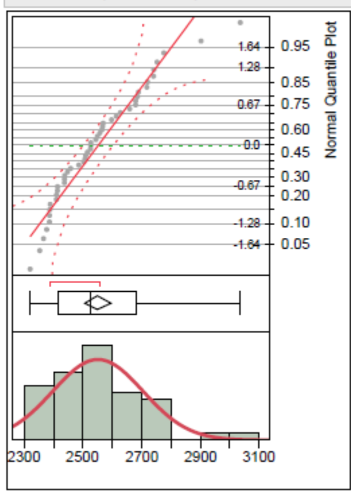
Shapiro-Wilk W Test

W	Prob<W
0.940376	0.0168 *

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Orleans

Rel. Profit (2011-2012)



Normal(2551.28,154.149)

Quantiles

100.0%	maximum	3037.53
99.5%		3037.53
97.5%		3010.71
90.0%		2744.43
75.0%	quartile	2679.98
50.0%	median	2526.88
25.0%	quartile	2413.53
10.0%		2383.97
2.5%		2326.34
0.5%		2319.77
0.0%	minimum	2319.77

Summary Statistics

Mean	2551.2773
Std Dev	154.14866
Std Err Mean	22.484892
Upper 95% Mean	2596.5371
Lower 95% Mean	2506.0176
N	47

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2551.2773	2506.0176	2596.5371
Dispersion	σ	154.14866	128.09367	193.60853

-2log(Likelihood) = 605.944460566997

Goodness-of-Fit Test

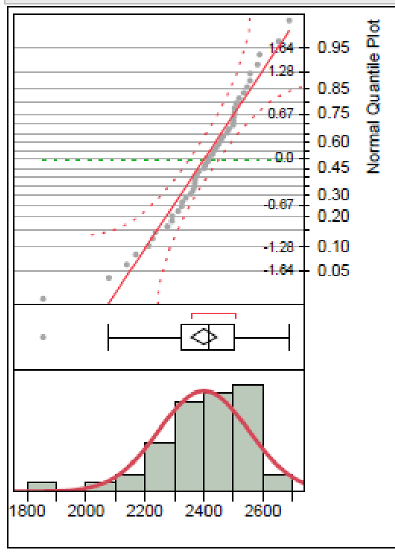
Shapiro-Wilk W Test

W	Prob<W
0.937253	0.0140 *

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Seneca

Rel. Profit (2011-2012)



Normal(2400.27,153.135)

Quantiles

100.0%	maximum	2690.67
99.5%		2690.67
97.5%		2682.71
90.0%		2559.89
75.0%	quartile	2504.39
50.0%	median	2414.93
25.0%	quartile	2324.96
10.0%		2208.54
2.5%		1903.95
0.5%		1853.65
0.0%	minimum	1853.65

Summary Statistics

Mean	2400.274
Std Dev	153.13482
Std Err Mean	22.103108
Upper 95% Mean	2444.7397
Lower 95% Mean	2355.8083
N	48

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2400.274	2355.8083	2444.7397
Dispersion	σ	153.13482	127.47996	191.81367

-2log(Likelihood) = 618.224698064793

Goodness-of-Fit Test

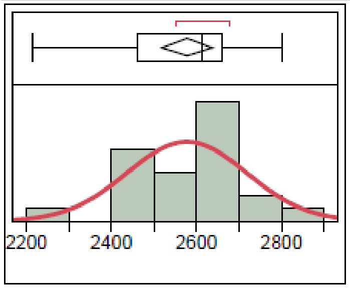
Shapiro-Wilk W Test

W	Prob<W
0.945156	0.0257 *

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Cayuga, Year=1

2011 Profit (SI)



Normal(2577.24,141.658)

Quantiles

100.0%	maximum	2801.14
99.5%		2801.14
97.5%		2801.14
90.0%		2789.65
75.0%	quartile	2660.46
50.0%	median	2612.16
25.0%	quartile	2460.65
10.0%		2408.6
2.5%		2211.94
0.5%		2211.94
0.0%	minimum	2211.94

Summary Statistics

Mean	2577.2417
Std Dev	141.65761
Std Err Mean	28.915738
Upper 95% Mean	2637.0584
Lower 95% Mean	2517.4249
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2577.2417	2517.4249	2637.0584
Dispersion	σ	141.65761	110.09822	198.71171

-2log(Likelihood) = 304.872870350312

Goodness-of-Fit Test

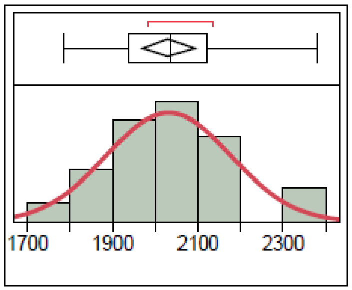
Shapiro-Wilk W Test

W	Prob<W
0.944368	0.2039

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Distributions Farm / Location=Cayuga, Year=2

2012 (SI)



Normal(2031.12,147.24)

Quantiles

100.0%	maximum	2381.67
99.5%		2381.67
97.5%		2381.67
90.0%		2261.81
75.0%	quartile	2122.68
50.0%	median	2036.18
25.0%	quartile	1937.37
10.0%		1832.46
2.5%		1784.32
0.5%		1784.32
0.0%	minimum	1784.32

Summary Statistics

Mean	2031.115
Std Dev	147.23996
Std Err Mean	30.055231
Upper 95% Mean	2093.289
Lower 95% Mean	1968.941
N	24

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2031.115	1968.941	2093.289
Dispersion	σ	147.23996	114.4369	206.54242

-2log(Likelihood) = 306.728104242214

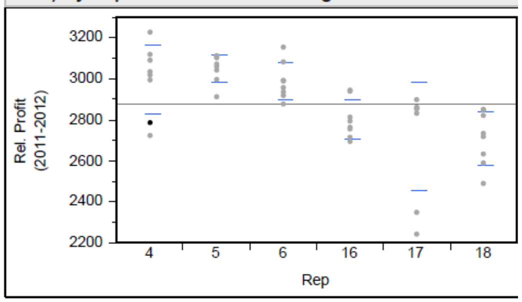
Goodness-of-Fit Test

Shapiro-Wilk W Test

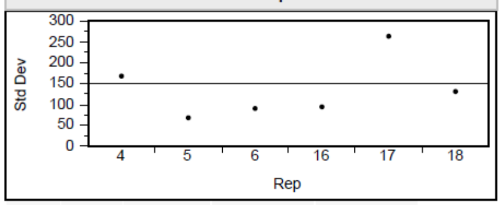
W	Prob<W
0.948912	0.2566

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Oneway Analysis of Rel. Profit (2011-2012) By Rep Farm / Location=Livingston



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
4	8	168.0302	123.4411	118.5762
5	8	68.2154	50.3374	48.1026
6	8	90.3664	66.0079	66.0079
16	8	94.3452	72.5184	70.3934
17	8	263.5300	211.7292	150.0566
18	8	131.1858	104.6726	102.7118

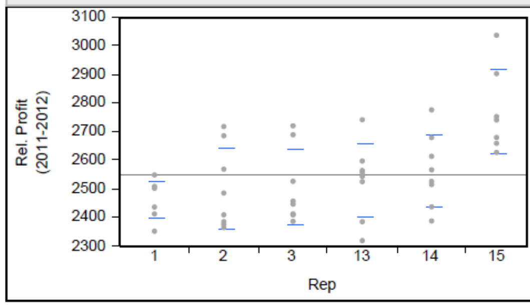
Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	2.4827	5	42	0.0466 *
Brown-Forsythe	0.7496	5	42	0.5910
Levene	3.9951	5	42	0.0047 *
Bartlett	3.3184	5	.	0.0053 *

Welch's Test

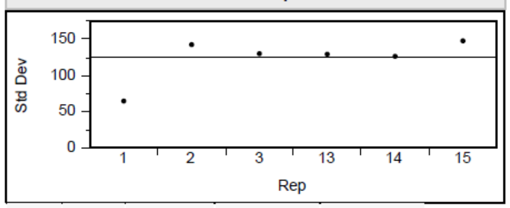
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
12.5730	5	19.203	<.0001 *

Oneway Analysis of Rel. Profit (2011-2012) By Rep Farm / Location=Orlean



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
1	8	64.6653	53.7717	53.7717
2	8	142.3611	118.6827	115.2662
3	8	129.9679	104.5055	92.3325
13	8	129.2028	89.5028	85.9034
14	8	126.2837	96.1544	96.1544
15	7	147.6482	113.4481	105.4240

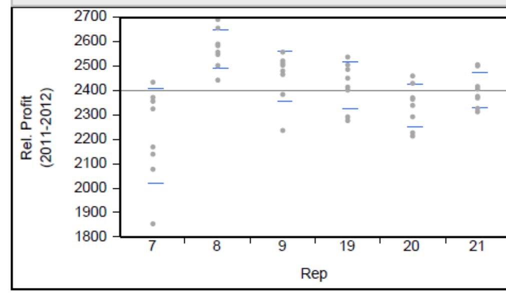
Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.6634	5	41	0.6533
Brown-Forsythe	0.4871	5	41	0.7839
Levene	0.8902	5	41	0.4965
Bartlett	0.9021	5	.	0.4785

Welch's Test

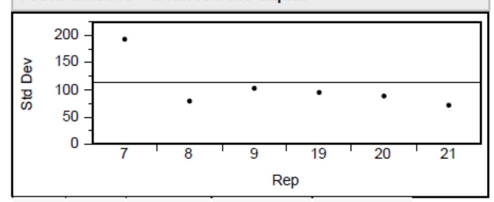
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
4.8319	5	18.482	0.0054 *

Oneway Analysis of Rel. Profit (2011-2012) By Rep Farm / Location=Seneca



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
7	8	193.2765	155.8612	155.8612
8	8	79.3297	58.8786	58.8786
9	8	102.8676	73.7150	65.9685
19	8	95.3119	74.3413	74.3413
20	8	88.5770	69.5646	69.0037
21	8	71.7571	55.4022	55.4022

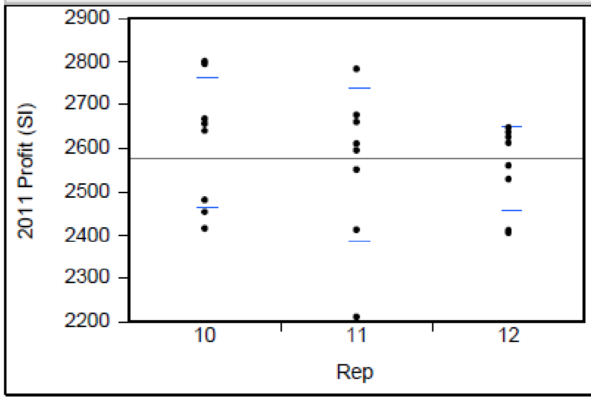
Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	2.1199	5	42	0.0818
Brown-Forsythe	2.5130	5	42	0.0445 *
Levene	2.9094	5	42	0.0241 *
Bartlett	2.0343	5	.	0.0705

Welch's Test

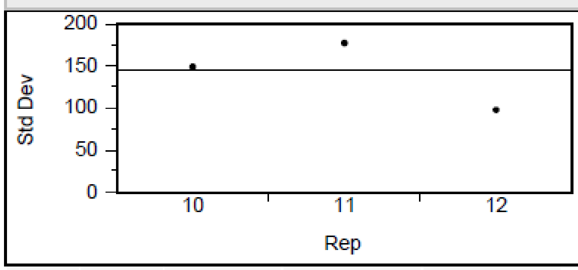
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
8.0755	5	19.448	0.0003 *

Oneway Analysis of 2011 Profit (SI) By Rep Farm / Location=Cayuga, Year=1



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
10	8	149.3417	123.0221	116.3870
11	8	177.6712	128.4517	120.1942
12	8	98.3055	78.9036	77.3377

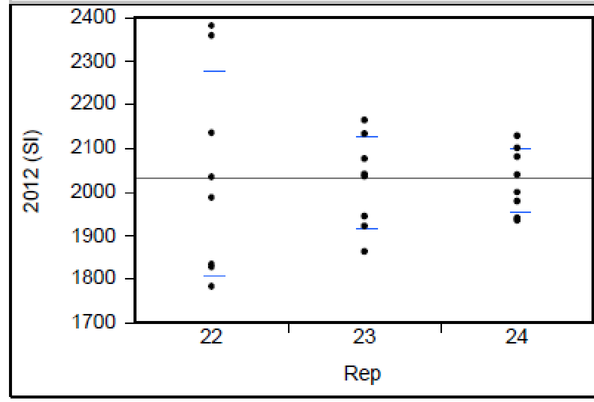
Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.9089	2	21	0.4182
Brown-Forsythe	0.4627	2	21	0.6358
Levene	0.8746	2	21	0.4317
Bartlett	1.0981	2	.	0.3335

Welch's Test

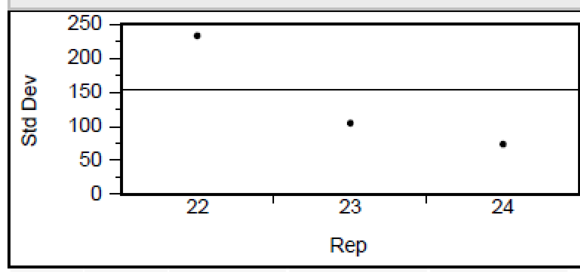
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
0.4388	2	13.113	0.6540

Oneway Analysis of 2012 (SI) By Rep Farm / Location=Cayuga, Year=2



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
22	8	233.5299	186.4482	184.3903
23	8	104.9511	84.3460	80.9623
24	8	73.5467	62.0107	62.0107

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	5.6712	2	21	0.0107 *
Brown-Forsythe	4.7934	2	21	0.0193 *
Levene	5.6471	2	21	0.0109 *
Bartlett	4.6217	2	.	0.0098 *

Welch's Test

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
0.0237	2	12.489	0.9766